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THE UNIVERSITY OF TORONTO AND THE MINERAL INDUSTRY*

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Part I

The Province of Upper Canada was founded under the Constitutional Act of 1791. During the preceding seven or eight years a United Empire Loyalist population had been sitting on the banks of the St. Lawrence, on the shores of the Bay of Quinte, in the Niagara Peninsula and on the shores of Lake Erie, and the population of the province at this time numbered about sixty-five thousand.

Seven years later, in 1798, a committee of the Executive Council, of the judges, and of the law officers of the Crown, recommended that five hundred thousand acres of land should be devoted to educational purposes, of which one-half should be reserved for the University, and that the University should be located at York.

In 1826 the Rev. John Strachan, M.A., Archdeacon of York, was commissioned to visit England and returned with a royal charter founding a university. The charter was dated the 15th of March, 1827, and on the 3rd of January, 1828, the new lands for endowment already selected were conveyed by letters patent to the Corporation of King's College thus created. Shortly afterwards, the Council of the College purchased at one hundred dollars per acre, one hundred and sixty-eight acres of beautiful park lands, on which have subsequently been built both the Parliament and University buildings.

King's College was opened in 1843 with these seven professorships: (1) Classical Literature, Belles-lettres and Logic; (2) Divinity, Metaphysics and Ethics; (3) Experimental Philosophy and Chemistry; (4) Mathematics and Natural Philosophy; (5) Anatomy and Physiology; (6) Law; (7) Surgery. The salaries of the professors in Classics and Divinity were £500 and of the other Arts professors, £450

A statute of 1844 provided for the establishment as soon as funds should be available, of chairs in (1) Hebrew and Oriental Languages; (2) Political Economy; (3) Medical Jurisprudence;

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* This article by Professor Haultain is now appearing in the "Canadian Mining Journal."

(4) Music; (5) History; Geography and Antiquities; (6) Geology and Mineralogy; (7) Civil Engineering; (8) Architecture; (9) Painting; (10) Agriculture.

Little progress, however, was made in these appointments for want of sufficient funds, and much trouble seems to have been caused by disputes over religious matters. The Anglicans, Methodists, and Presbyterians were active fighters. We are told that Bishop Strachan and his friends attacked the University as a "godless institution."

In 1850 King's College became the University of Toronto, and again a special committee recommended the appointment of professors in Civil Engineering and in Geology, as well as in Agriculture and other subjects.

In 1853 the chairs of Natural Philosophy and Natural History were founded and John Tyndall was an unsuccessful applicant for the first and Thomas Huxley for the second.

In 1856 Professor E. J. Chapman was appointed Professor of Mineralogy and Geology, a position he held for forty-two years, retiring in 1898.

In 1858 the crowning stone of the beautiful Main Building was laid by the governor, Sir Edmund Walker Head. The original plans for this building were curtailed for want of money, and, notwithstanding, the cost considerably exceeded the appropriation. This seeming extravagance in the building was, as most friends of the institution now think, justified by the result. The Hon. Edward Blake, addressing, as Chancellor, the annual convocation in 1884, said, "We sometimes hear murmurs as to the wisdom of their erection, but those who know as I do—though I was but a young man at that time—all the circumstances of the University when that policy was adopted, know that these buildings were in a marked sense the sheet anchor of the institution in the storms which at one time threatened to subvert it." The new buildings were opened for academic purposes in 1859, and from this point dates an era of greater prosperity for the University; but it was not until nearly twenty years later that a further step was made towards the benefit of the mineral industry. The statute of 1844 provided for the establishment of a chair in Civil Engineering, but it was thirty-four years before this was carried out.*

In 1877 the Legislative Assembly, by Resolution, sanctioned the proposals for the permanent establishment of the School of Practical Science of the Province of Ontario. These proposals were in effect that the Government should utilize the teaching power of University College, which already existed for the like objects in four departments, and could be made applicable to the wants of this Science School; and in addition thereto should appoint a Professor of Engineering and such assistants in the several departments as might be required in supplementing the work of the College Professors.

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* Most of this has been taken from "The University of Toronto and its Colleges, 1827-1906."
—Edited by W. J. Alexander, Published by the Librarian, 1906.

."The position which it is intended the School of Practical Science shall satisfactorily occupy in the Educational System may be indicated as follows:—

Firstly—Students who have passed through the regular courses of the School will be enabled to prosecute professionally, (1) Engineering; (2) Assaying and Mining Geology; or (3) Analytical and Applied Chemistry.

With this view the Diploma admitting to the standing of "Associate of the School" will be granted in each of these branches after due examination.

In Engineering it is intended that the instruction shall afford a thoroughly scientific basis for operations in the field. In the absence of a machine shop and of facilities for visits to mines during session, visits to workshops and excursions during the long vacation will be taken advantage of. The establishment of a diploma for special qualifications in Assaying and Mining Geology, apart from the knowledge of these subjects incidental to the course in Mining Engineering is sufficiently called for by the necessity which exists for the development of the mineral wealth of the province. Students who pass through the course necessary to obtain this diploma will have acquired the knowledge requisite for inspecting and surveying mineral lands, as well as the ability to report accurately on the composition and value of economic minerals generally.

The importance of the study of Chemistry is now fully recognized, and in Canada, through the Public Analysts and otherwise, protection is being secured to consumers, while the producers are necessarily brought to recognize its importance. The course in Chemistry will be such as to fit the student for the position of Public Analyst or of Consulting or Resident Chemist.

Secondly.—It is proposed to furnish preliminary scientific training for students entering the professions of Surveying and Medicine. The certificate to be granted in Surveying will be attainable by one year's study, and it is intended that this should entitle its possessor to appear one year earlier for his examination as Provincial Land Surveyor."*

The School so constituted was opened on October 1st, 1878, with the following staff:—

H. H. Croft, D.C.L., Professor of Chemistry and Chairman of the Board.

E. J. Chapman, Ph.D., LL.D., Professor of Mineralogy and Geology.

James Loudon, M.A., Professor of Mathematics and Natural Philosophy.

R. Ramsay Wright, M.A., Professor of Biology and Secretary of the Board.

J. Galbraith, M.A., Professor of Engineering.

W. H. Ellis, M.A., M.B., Assistant to the Professor of Chemistry.

The first four were professors in University College.

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* From the Prospectus of the School of Practical Science of the Province of Ontario, First Session, 1878-1879.

It will be seen from this that from the very start the "School," as it was then known, was prepared to do much for the mineral industry. Not only was Engineering to include Mining Engineering, but there was a special course in Assaying and Mining Geology with a diploma attached equal in dignity to the diploma in Engineering. The Professor of Mineralogy and Geology was a remarkable and interesting man, a skilful fencer and a poet, as well as a scholar and teacher. He was educated mainly in France and partly in Germany, enlisted in the French army, and served an actual campaign in Algiers. He was also Professor of Mineralogy in University College, London, before coming to Toronto. He was a voluminous writer on Canadian Geology, on Assaying, and on Blowpipe Analysis. This course in Assaying and Mining Geology remained in force until the session of 1892-93, when it was replaced by the department of Mining Engineering; but I can find no record of any student having earned a diploma in this course.

The course in Analytical and Applied Chemistry appeared to be unpopular, as the records show that no diploma was issued in this course until 1890, by which time seventy-nine diplomas had been granted in the course in Engineering.

This course in Engineering would appear to be the most remarkable development in the history of the University, remarkable alike in the rapidity of its growth and in the consistency of its development. The central figure, in fact an isolated figure, in this development is that of the Professor of Engineering, afterwards Principal of the School and later when it was absorbed into the University, Dean of the Faculty of Applied Science and Engineering. It is probable that no other large department of any University in Canada has grown with such rapidity, nor has any other department of the University of Toronto with a live activity, departed less from the general direction laid down for its growth in its early stages. That the growth is so strong and so persistent is evidence of the closeness of the course to the needs of the country. This general engineering course is the backbone of the work that the University is doing for the mineral industry and will continue to be so.

John Galbraith graduated in Arts in the University of Toronto in 1868, winning, in his course, the Prince of Wales Prize for General Proficiency, and the Gold Medal in Mathematics, besides other prizes. The following years were spent in a variety of engineering work in both the mechanical and civil branches.

He was appointed Professor of Engineering in 1878. For the first few years of the School's existence he did all the Engineering teaching, including drawing and surveying.

W. H. Ellis, M.A., M.B., who had been associated with the School from the start, was appointed Professor of Applied Chemistry in 1882. In 1889 L. B. Stewart, Ph.S., D.T.S., joined the staff as Lecturer in Surveying, and the following year two of the School's own graduates returned, C. H. C. Wright as Lecturer in Architecture, and T. R. Rosebrugh as Demonstrator in the Engineering Laboratory.

In this year the School was affiliated to the University, the Professor of Engineering was appointed principal and the management of the School was transferred to a Council, consisting of the teaching faculty of the school and not including the Arts professors, who continued, nevertheless, to give instruction in their respective subjects to the School students. From this time on there was a steady growth in the staff until the present. There are now twenty-eight professors, associate professors and lecturers in the Faculty of Applied Science alone, besides a large number of demonstrators and fellows. This is in addition to the Arts professors in Mathematics and several other subjects, who still teach the Engineering students.

The first prospectus of the School does not contain the name of the Professor of Engineering; he was appointed after its issue, but in time for the first session. The first syllabus of the course in Engineering is very different from the one drawn up after his appointment. The syllabus of the second prospectus remains to the present the main framework of the department of Civil Engineering. It has grown, it grew continuously, it has been elaborated and to some extent modified, but the main lines have remained. The course to-day resembles the course of 1880 as the mature oak does the sapling. The latest change in the course, by some considered a radical departure, the addition of four lecture courses in business and finance is simply the blossoming of a bud that was shown to me many years ago and was probably a suppressed feature of a much earlier stage.

The main features of the course are, a groundwork of pure mathematics, a broad training in principles, followed by illustrations of the applications of the principles. The practice of Engineering is left to be learnt in the field. The exception to this is in surveying and draughting, and chemistry, where the student is given sufficient of the practice to make him a useful man in these subjects immediately on graduating. Engineering is so wide and the time of the academic period so limited that very much that would be desired must be left out of the course. Everything has been made subservient to the idea of the application of principles. Mathematics is for the preparatory mental training. The heavy course in principles keeps their application always in view. To this is added facts, methods and processes sufficient for the course in the application of principles. As the time is so short only the application of main principles can be illustrated. The whole is designed to enable and cause the boy to go on after graduation with the training which has only been commenced in the University. "We do not make engineers" has been the oft reiterated statement for thirty years of the Professor of Engineering; "We prepare them to become engineers."

Laboratories have been added, but not workshops, laboratories for the illustration and examination of principles. Only draughting, surveying, assaying and chemical analysis have their equivalent of shop work, but in each of these the elucidation of principles takes precedence over the practice. There has been a splendid and careful development of laboratories in every direction.

The duration of the course was three years and in each year there were twenty-five weeks of actual teaching time, the summers were to be spent at work in the field. Examinations were held at the end of each session and the diploma of the School was granted on the satisfactory completion of the course.

After a graduate had spent three years in the actual practice of his profession, two years of which must have been on the construction and operation of engineering works as distinct from surveys merely, he could become a candidate for the degree of C.E. of the University, which was granted after the candidate submitted a satisfactory essay with drawings and estimates. This regulation was afterwards enlarged to include the degrees of M.E. (Mechanical Engineer). M.E. (Mining Engineer), and E.E. (Electrical Engineer). These degrees have not been popular with the graduates, the trouble being that anybody can put these letters after his name, with the result that it is generally the impostor who does so. But the intention of the University is well worthy of notice.

A degree that called for three years of actual work in the field is something very unusual and it is a great pity that circumstances should have belittled the use of these letters.

In 1892 an optional fourth year was added to the three years' course, and on the satisfactory completion of this year the degree of Bachelor of Applied Science (B.A.Sc.) was granted to the candidate by the University.

Some of the regulations governing the granting of this degree were as follows:

3. Each candidate shall prepare a thesis based on the results of his Fourth Year work in the said School of Practical Science for the approval of the University Examiners. This thesis is to be accompanied by all necessary drawings, specifications, tables and estimates.

4. Candidates will be required to select two subdivisions in any one of the following groups, and to pass such written and oral examinations on the subjects selected as may be prescribed by the University examiners.

A.—Astronomy.
    Geodesy and Metrology.

B.—Architecture.
    Strength and Elasticity of Materials.
    Hydraulics.
    Thermodynamics and Theory of Heat Engines.
    Electricity and Magnetism.

C.—Industrial Chemistry.
    Sanitary and Forensic Chemistry.
    Inorganic and Organic Chemistry.

D.—Mineralogy and Geology.
Metallurgy and Assaying.

As the laboratories in all departments have grown the work of this fourth year became largely laboratory work. The students had the opportunity to specialize along their own lines and it was a very satisfactory arrangement.

The three year course for the diploma has now been done away with and students commencing during the past three years have entered on a four year course leading to the degree of B.A. Sc. This has permitted a re-arrangement of the curriculum and somewhat reduced the freedom of the fourth year. This was necessary as the work of the first three years had become much overcrowded.

It is hoped that before long an optional fifth year leading to a higher degree will be added.

In 1880 the diploma of the School was granted in "Engineering" and the studies could be pursued along three optional lines, Civil, Mechanical and Mining. In the session of 1890-91 this was subdivided into (1) Civil Engineering (including Mining Engineering), and (2) Mechanical Engineering (including Electrical Engineering). The following year Architecture was added. In 1892-93 Mining Engineering became a separate course and Civil Engineering "included" Sanitary Engineering.

At the present time the separate courses stand as follows:—

1. Civil Engineering.
2. Mining Engineering.
3. Mechanical Engineering.
4. Architecture.
5. Analytical and Applied Chemistry.
6. Chemical Engineering.
7. Electrical Engineering.
8. Metallurgical Engineering.

In 1880 the fees for the course paid by the student amounted to $160. This has been raised from time to time until it now amounts to $450. The standard of scholarship required for entrance has also been steadily raised. Despite these facts the growth in attendance has been rapid and steady.

The Government Blue-book covering the work of the University for the year ending 30th June, 1911, shows 779 students in the Faculty of Applied Science, and Engineering, of whom 99 were in the department of Mining Engineering.

The distribution of the students in the different subdivisions of the University was as follows:

University College—Arts	1086
Victoria College—Arts	516
Trinity College—Arts	140
St. Michael's College—Arts	46
Medicine	567
Applied Science and Engineering	779
Household Science	101

Education	262
Forestry	46
University of Toronto—Candidates for Ph.D., M.A., Dentals, Vets., etc	576
Total	4112

Of this large number 1,018 were women and 3,094 were men. As there were 311 women students in University College there were more men students in the Faculty of Applied Science and Engineering than in any other subdivision of the University, though the combined group of Arts students in the various colleges would, of course, outnumber them.

President Falconer in an article contributed to the "University Monthly" in 1909, said: "Unless all omens fail the Faculty of Applied Science will soon become the second in size in the University and may creep up upon the Faculty of Arts, though Arts has such a lead that it will probably hold the first place for many years. During the last two years, not including the present, the ratio of increase in the Faculty of Applied Science has been thirty-two per cent., a larger proportionate increase than in any other Faculty.

"This Faculty has developed healthfully and in conformity with the demands of the country. Ontario has become a great manufacturing province without, at the same time, ceasing to develop its agriculture. The Agricultural College at Guelph is a splendid evidence of the good hope that lies before our farming population. For the other side of our life we also need leaders—in opening up new country by railways, in constructing large works, in developing mines. For producing men who will direct these activities there is the Faculty of Applied Science, formerly known as the School of Practical Science.

"A distinction must be kept clearly in mind. The aim of the Faculty of Applied Science is not to be confounded, as is sometimes done, with the work of technical education. The latter consists on the one hand of giving artisans and the youth in school instruction in the scientific principles that underlie the various trades in which they may be engaged, and on the other hand of instruction in the principles and technique of the actual trades. Technical education is meant for the man who whether as foreman or skilled workman, is engaged in some trade.

. . . .

"In the Faculty of Applied Science, however, students are being trained who will become the directors of the works in which the technically trained men will be employed."

(*To be continued*)

CONCRETE IN SEWER CONSTRUCTION

By W. J. Baird, B.A. Sc.

The superior qualities of concrete as a structural material are being more fully realized every day. In almost every kind of structural work it is competing successfully with older and better known materials. When any new material is introduced into the field of engineering, it has to undergo a period of trial, in which it receives much undue criticism owing to failures due more to inferior design and careless workmanship, than to any inherent defect in the material itself. Concrete was no exception to this rule. In the case of most kinds of work in which concrete has been used, its capabilities are now well-known, the methods of design are now fairly familiar to the engineer, and concrete structures can be built with at least as much assurance as to their safety and reliability as is possible with any other material.

In one class of work, however, concrete has not yet reached that safe and unassailable position in the ranks of structural materials that it has in many other classes and that its advocates claim is due it in this. That is in the use of concrete as a material for sewer construction. Concrete has been used for many years in the building of sewers, but cases of failure of concrete sewers have been so numerous and evidences of its reliability so conflicting, that there is even yet considerable doubt as to its adaptability under certain circumstances, and to its relative advantages compared to brick and vitrified clay pipe, the other most commonly used materials in sewers.

This condition of affairs arises from several causes; firstly, the fact that the work is covered up soon after completion, often makes it difficult to discover whether any subsequent failure was due to defective material, or to an accident arising from some combination of circumstances which it was difficult to foresee and make provision for; secondly, there are few classes of work in which apparently trifling defects, such as insufficient mixing of concrete or misplaced reinforcement, may lead to such disastrous results; thirdly, when a concrete sewer fails, the fact is advertised far and wide over the country by people who are interested in the sale of other sewer materials, such as vitrified clay products.

Concrete sewers have been in use for many years in Europe, and to a lesser extent in America. Paris, France, has probably more miles of concrete sewer than any other city. Brooklyn was one of the first American cities to use cement sewer pipe to any great extent; for many years their specifications required concrete pipe to the exclusion of other kinds. Wilmington, Delaware, was one of the first cities to construct monolithic concrete sewers. Many of these early sewers were constructed of natural cement concrete. Some of these have failed, and these failures have had a tendency to put concrete into disrepute as a safe and economical material. Since the introduction of Portland cement concrete into common use, however, many sewers have been constructed of Portland cement concrete, which seems to fulfil all the requirements of a perfect sewer. Among the cities that have used concrete sewers somewhat extensively might be mentioned,—Chicago; New York; South Bend, Ind.; St. Joseph, Mo.; Toledo, Ohio; Cleveland, Ohio; Wilmington, Del.; Great Falls, Mo.; Philadelphia, Pa.; Truro, N.S.; Toronto and Hamilton, Ont., and many smaller places in both the United States and Canada.

Notwithstanding their wide use, many municipal engineers are somewhat diffident about adopting concrete for sewers, even though they admit that concrete is usually somewhat cheaper than the other materials in common use, and they have no definite reason for supposing that it is inferior to brick or vitrified pipe. This is due, doubtless, to the somewhat prevalent idea, that concrete is susceptible to the action of chemicals in sewage, and that concrete sewers are inferior in strength and impermeability to those constructed of brick or tile.

In this article it is proposed to make some investigations as to how concrete sewers compare with those of other materials in:

1. Their ability to resist the disintegrating of chemicals liable to be present in the sewage or ground water.
2. Their ability to resist the erosive action of fluids passing through them.
3. Their general suitability as sewage carrying channels.
4. Their ability to withstand the external pressures and shocks to which they are liable to be subjected.
5. Their cost.

It is also intended to give a short description of the different forms of concrete sewers which have been constructed and some examples of sewers now in use in various cities.

Resistance to Chemical Disintegration

The ground upon which concrete as a sewer material has been most attacked, and upon which it still remains the most open to attack, is with regard to its ability or lack thereof, to withstand the action of chemicals with which it is liable to come into contact. The makers of cement sewer pipe confidently assert that their product is proof against, not only the somewhat diluted chemicals usually found in sewage, but also against the most powerful combination of chemicals that the ingenuity of a chemist could devise. On the other hand, the manufacturers of vitrified clay pipe and sewer brick spare no expense in providing possible purchasers of their products, with apparently incontrovertible proofs that concrete is not only liable to be disintegrated by sewage, but that it is also easily dissolved away by the action of pure water alone. The truth must lie somewhere between these two statements, just where, there is none too great a wealth of evidence to show.

The disintegrating agent may arise from the sewage or from external agencies, such as the ground water. In the first case the immediate agent of destruction may be in the sewage itself in the form of dilute acids or alkalis, or it may be in the form of gases given off by the sewage. This case shall be considered first.

An often-quoted example of the disintegration of concrete by sewage gases is in connection with the sewage disposal works at Hampton, England. The history of the case was given in a paper read by Mr. Sidney H. Chambers, engineer to the Hampton Council, to the members of the Concrete Institute. In connection with the hydrolysing chamber and the inlet channel it was noticed that the concrete was being decomposed. Upon examination it was found that the concrete that was always under water was perfectly sound, while that high above the water was only slightly affected. The area of maximum decomposition was included between the low and high water levels of the sewage. The concrete where it had been attacked by the sewage gases was found to be covered with a white chalky substance which analysis proved to be sulphur. The concrete under this, upon being analyzed, was found to contain a large percentage, varying from sixty-five to seventy-five, of sulphate of lime.

The explanation given for this ran as follows: the main erosive effect was at the varying liquid level, and was there dependent upon the amount of sulphuretted hydrogen in solution in the liquid. The gas was comparatively small in amount in the incoming sewage but increased as the liquid passed through the hydrolysing chambers owing to increased putrefaction. When the level of the liquid fell it left the concrete which it previously covered, wetted with a liquid containing sulphuretted hydrogen in solution. This wet surface was then exposed to the air which oxidized the sulphuretted hydrogen, forming sulphurous and sulphuric acids, which, acting on the concrete, changed the lime to sulphate of lime. The active agent was probably sulphurous acid as concrete is not affected much by sulphuric acid. When the liquid rose again the decomposed material was washed away, and a fresh surface exposed to the action of the sewage when the liquid fell again. It was the continuation of this cycle that led to the formation of the grooves at the varying liquid level.

The erosive effect on the concrete above the liquid level was dependent upon the sulphuretted hydrogen evolved from the liquid and mixed with the air supply. Some of this gas was dissolved by the moisture which was present on the walls and roof from evaporation and condensation; it was then oxidized by the air and decomposed the concrete, as described above.

The conclusions drawn from these investigations were, that gases in solution in sewage and those expelled from it do not act injuriously on Portland cement concrete, provided all the following conditions occur at the same time:—

1. A high degree of putrescence in the sewage.
2. A moistened surface which absorbs the putrid gases.
3. The presence of a free air supply.

This case has sometimes been quoted as direct evidence of the inferiority of concrete as a sewage-resisting substance, but if a close examination of the situation is made, it will be seen that there are extenuating circumstances which make the situation not as bad as it seems. In the first place, of the many sewage purification plants, this is one of the few from which there has been like trouble reported; secondly, since, as it is distinctly intimated in the report, there is necessary before sewage gases can have any effect on the concrete, a high state of putrefaction, such as could never exist in a properly designed and constructed sewer, to attempt to introduce this as an argument against the use of concrete in sewers appears to be misapplied energy.

A somewhat similar case has been reported from Amherst, Ohio. Here the Ohio Quarries Co. have a small purification plant to care for the sewage of about eleven dwellings. This plant was built in 1905 and consists of a covered septic tank and continuous filter. Being so small there is quite a variation between the low and high levels of the sewage. Disintegration of the walls of the septic tank was noted in March, 1910, and was found to be most pronounced along the strip between the ordinary flow level and the high level caused by increased flow in times of storm. The writer gives it as his opinion that sewage will attack concrete if there is much putrefaction taking place, especially if the concrete is of anything but a dense impervious mixture.

In the reconstruction of a large sewer (15′ x 20′) in St. Louis about eight years ago, concrete was used both with and without a covering of vitrified bricks in adjoining portions of the sewer. The section covered by the vitrified brick seems to be the most satisfactory. The surface is hard and smooth and no appreciable wear can be detected. The surface of the concrete section not covered with vitrified bricks is completely pitted with small holes from one quarter of an inch to one half an inch in diameter and depth. The Portland cement mortar seemed to be partially disintegrated. When new, the mortar was allowed to harden for several days before sewage was allowed to pass over it. The cause of this pitting has not yet been determined.

In the proceedings of the Institute of Civil Engineers for November, 1908, Mr. Barnett described some investigations he made in connection with the detection of water losses in the Thurlmere Aqueduct, which supplies Manchester with water. The aggregate of the concrete was here composed of pure limestone, and it was found that where the limestone was exposed to the water, marked cuppings were visible, showing that the limestone was being dissolved by the water while the water was unaffected. Mr. Barnett made some tests to confirm this. He submitted a block of each of the following, limestone, cement mortar and neat cement, to the action of the water. He found that the limestone was the only one of the three to be appreciably affected, and it was found to have lost a considerable percentage of its weight.

It is a well known fact that water unites with carbon dioxide gas, forming an acid which reacts chemically with limestone. Hence, water which contains a quantity of this acid will have a destructive effect on limestone with which it is brought into contact. Since carbon dioxide is evolved wherever there is any decomposing organic matter, it is practically certain to be present in sewage. It would appear to be a necessary precaution to exclude limestone from the concrete to be used in sewer construction. In the results of the experiments just mentioned may lie the explanation of the action of the St. Louis sewer. However, a more detailed knowledge of all the contributory circumstances would be necessary before any definite conclusion could be made.

It would appear that fear of the concrete being attacked by gases present in the sewage is ill founded, while before it could be decided as to the probability of the sewer being destroyed by chemicals in the sewage itself, an examination of the sewage to be carried and of the concrete aggregate would have to be made. However, it is evident that any sewage having a deleterious effect on a concrete sewer would have the same effect on the cement mortar of a brick, and to a lesser extent on the joints of a vitrified pipe sewer. That brick sewers are not altogether immune from the attack of strongly acid sewage is shown in the case of a sewer in Halton Borough, England. where a brick sewer was completely disintegrated by acids allowed to drain into it from silversmiths' and goldsmiths' workshops.

The opinion of municipal engineers as to the effect of sewage on concrete is far from unanimous. The mayor of Kansas City obtained the opinions of a number of prominent engineers, among whom were the city engineer of Jersey City, Mr. E. S. Rankin, C.E., and Alexander Potter, C.E., of New York, all of whom gave it as their opinion that the danger of sewage having any effect on concrete was inappreciable. On the other hand there have been published letters from several engineers, for instance, the city engineers of Terra Haute, Indiana, and Worcester, Mass., in which they gave as their decided opinion that concrete sewers are liable to be disintegrated by sewage. On the whole there seems to be little to justify the contention that concrete sewers are liable to failure from the attacks of chemicals in the sewage.

A common cause of the disintegration and consequent failure of concrete sewers is the presence of the sulphates, chlorides and carbonates of magnesium, calcium and potassium in the ground water. Of these the sulphates appear to be the most active. Cases of this nature have been noticed in the arid regions of the Western States and India, and in Prussia.

Mr. J. G. Jewett, of the U. S. Reclamation Service, gave before the American Society for Testing Materials in 1908, certain information regarding the effect of these alkaline charged waters on concrete culverts in Montana and Wyoming. Considerable disintegration was found to take place near the water line. This seemed to consist largely of the formation of crystals, which was accompanied by considerable expansive force. Experiments made by Mr. W. P. Headden, of the Fort Collins Experimental Station, indicate that cement concrete is very susceptible to the action of weak solutions of the above mentioned alkali.

Preliminary to the construction of a reinforced concrete pipe line in Idaho through alkali soil, some investigations were made to determine the probable effect of the alkalis on the concrete. A test length of pipe was placed in a slough where it would be exposed to the action of alkali under the most severe conditions that could be devised. Up to the present, six months later, no effect that can be detected has developed. This experience seems to be somewhat unusual.

The case of the sewers at Great Falls, Montana, has been frequently referred to and is, probably, the most striking illustration of the deterioration yet considered. The City Engineer, Mr. C. W. Swearingen, was so impressed by the conditions that he requested an expert from the Montana State Agricultural College to report it. The report is embodied in Bulletin No. 60 of the Montana Experimental Station, from which the following extracts are taken:—

"The Third Street main sewer was built in 1890, the material used being Portland cement pipe of home manufacture made in molds and put in place after the cement had hardened. The sewer is oval, 20 inches by 32 inches. This sewer, after a comparatively short term of service, showed defects so serious as to necessitate rebuilding portions of it. The remaining portion of the sewer has disintegrated in many places and pieces of the pipe are gone.

"The Sixth Street sewer was constructed in 1892, circular in form with an inside diameter of four feet, being composed of two rings of brick laid on edge in 1 : 3 Portland cement mortor with an outside plaster coat one-half of an inch thick but not plastered on the inside. The masonry in the invert is disintegrated almost its entire length. There is no subdrain under or along the sides of the sewer."

The results of the examination are synopsised as follows:

(a) The disintegration and destruction of the cement was not due to adulteration or to the quality of the materials used.

(b) Though a limited chemical and physical action of the alkali salts may be a partial cause of the breaking down of the brick, yet the primary cause was that the bricks were too soft, and not fit for sewer construction.

The analyses embodied in the report show that the maximum disintegration occurred where the greatest percentage of alkali salts showed in the soil, and that the ground waters were leaching the alkalis from the soils and depositing the salts along the sewer. The authors of the report consider the use of concrete sewers in alkali soils as inadvisable, where it is not possible to drain all the ground water from the exterior of the sewer. They recommend that drain tile be placed in the bottom of the trench and covered with gravel or crushed stone, and that similar drains be placed around the barrel of the sewer to provide drainage for the storm water, in order that it may not come into contact with the sewer. Where these precautions cannot be taken they "unhesitatingly recommend that cement pipe be not used."

At Lake Loveland in 1894 a tunnel for conveying water was lined with concrete. Ground impregnated with alkalis was met with in large quantities, but by providing large and efficient side drains it was possible to keep the ground water away from the concrete, with the result that fifteen years later the concrete is apparently as good as new.

In connection with some reclamation work in the United States it was discovered that the only convenient sand supply contained three per cent. of alkalis, which had a deteriorating effect on the concrete in which it was used. Apparently in some regions it would be necessary to investigate the composition of sands intended to be used in making concrete.

In connection with all these failures it has been noticed that the more porous a concrete is, the more liable it is to disintegration by alkali waters, and so a dense mixture of concrete should always be obtained where it is liable to be attacked by alkalis.

Dr. Rudolph Hering, in discussing the paper read by Mr. Anderson, before alluded to, describes a rather peculiar failure of a concrete sewer in Prussia. In this case the sewer had been laid in peaty ground which had as one of its most prominent constituents, iron pyrites. It was discovered that this pyrites was providing the sulphur for the formation of sulphurous acid which was attacking the concrete. In a similar case at Charlottenberg the concrete was protected by three layers of asphalt paper covering the concrete entirely.

At the annual convention of the Illinois Society of Engineers and Surveyors, the Committee on Sewers gave as their opinion that there was little to fear of concrete being injured by alkali soils in arid regions, and in any case solvents would prove as injurious to the cement mortar of a brick sewer as to a concrete sewer. Upon what evidence this conclusion was based is not recorded.

From the foregoing it may be concluded that if concrete sewers are to be built in alkali regions, some, or preferably all of the following precautions must be observed:

1. The ground in the immediate vicinity of the sewer must be so well drained that very little, if any, ground water is allowed to come into contact with the sewer.

2. The concrete must be made as nearly impervious as possible by using dense mixtures of concrete or by the addition of some waterproofing compound.

3. The outside of the sewer may be protected by means of some waterproof coating, such as asphalt or tar paper.

As for the contention sometimes made, that concrete is soluble in pure water, this seems too absurd to require any denial, in view of the fact that there are large numbers of concrete structures successfully withstanding the dissolving action of all kinds of ordinary water. On January 23, 1908, Mr. G. C. Wheat read before the Iowa Brick and Tile Association a paper in which he attempted to prove that concrete is soluble in water. He gave the results of some tests which he had made in which he submitted blocks of concrete to the action of distilled water. He found that the concrete after being about ninety hours in the water, had lost a small percentage of its weight. From this he concludes that the concrete, if left in the water long enough, would be entirely dissolved, assuming apparently, that the rate of solution would remain constant. But, as Mr. P. Gillespie points out, in referring to this paper, the rate of solution is probably not constant, and the loss in weight may be due to the dissolution of some minor soluble elements in the concrete, such as calcium sulphate, which is added in small quantities to cement in order to retard the set. Apparently the loss in weight of concrete due to the action of comparatively pure water is inappreciable.

Ability To Resist Erosion

There has been an idea prevalent for many years among the builders of sewers that concrete is inferior to sewer brick, in its power to resist the erosive action of sediment-carrying sewage. Just how this idea originated and how much foundation for it there is in fact, is difficult to say. But the result of the belief has been that about two-thirds of the concrete sewers constructed have had their inverts lined with some supposedly harder material, such as vitrified tile plates.

It is difficult to understand why concrete sewers should be less able to resist erosion than those constructed of other materials. In other structures, sidewalks for instance, concrete shows an abrasive resistance equalled by few, if any, other materials. Experiments to determine the relative powers of resistance to abrasion of the various materials used in sewer inverts are not numerous. One series of experiments have, however, been made by Mr. G. S. Rankin, and presented in a paper read before the American Society of Municipal Improvements.

In introducing the subject of the wear of sewer inverts Mr. Rankin instances the case of a brick sewer, six thousand feet long, which came under his observation in which the invert was completely worn through and had to be renewed at a considerable expense. He also quotes the following instances from Folwell's "Sewerage."

"A five and one-half foot two-ring brick sewer in Baltimore, twenty-five years old, was recently found with its invert cut completely through for a width of twelve to fifteen inches and badly worn to the height of two feet. In Omaha, brick sewers, the wear of which is usually eighteen inches to twenty-four inches wide, became from two to five inches deep in twelve years."

In Newark, N.J., a brick sewer built in 1886, size forty-five inches by sixty-nine inches, with a grade of 1.6%, was found to have its invert almost completely worn through in 1910. As a result of this wearing, it has been the custom to line the lower third or quarter of the cross-section with vitrified paving brick. The only test required was that the brick should not absorb more than two per cent. of its weight in water after being thoroughly dried, and immersed in water for twenty-four hours.

Experiments were made by Mr. Rankin with the idea of determining the relative wearing qualities of several materials and their consequent suitability as materials for sewer inverts. The samples were first tested for absorption and then placed on a rubbing machine such as is used in stone yards for rubbing blocks of stone. The samples were all twenty pounds in weight and were left on the machine twenty minutes, the velocity of the rubbing machine being at the rate of twenty-one feet per second. The results of the experiment were as shown in the following table:—

No.	MATERIAL	% Gained by Absorp.	% Lost by Abras.	Ratio Absorp. to Abras.	Life of Invert in years	Remarks
1	Vitrified Shale Brick.....	1.36	2.00	1 : 1.47	324	The life of the invert in years is calculated by assuming the life of No. 8 as 10 years.
2	Vitrified Shale Brick.....	2.15	3.35	1 : 1.56	193	
3	Vitrified Shale Brick.....	3.60	3.42	1 : .95	189	
4	Vitrified Shale Brick.....	4.28	5.92	1 : 1.38	109	
5	Shale Sewer Brick.......	13.18	27.31	1 : 2.07	24	
6	Building Brick..........	7.39	20.41	1 : 2.76	31	
7	Building Brick..........	10.19	44.74	1 : 4.39	15	
8	Building Brick..........	18.91	64.74	1 : 3.42	10	
9	1 : 2 Cement Mortar.....	11.86	4.41	1 : .37	147	
10	1 : 2 : 4 Grav. Concrete	6.65	3.82	1 : .57	169	
11	1 : 2 : 4 Grav. Concrete	5.10	3.35	1 : .66	193	
12	1 : 2 : 5 Stone Concrete	7.40	8.62	1 : 1.16	75	
13	Vitrified Tile...........	1.34	4.47	1 : 3.34	145	
14	Vitrified Pipe...........	4.47	6.11	1 : 1.37	109	
15	Vitrified Pipe...........	1.72	4.55	1 : 2.65	142	

TABLE No. 1

Specimens Nos. 1—4 were vitrified shale paving brick selected for their variation in absorption. No. 5 was a small shale brick made for use in sewers. Nos. 6, 7, and 8 were different makes of building brick, also selected for their variation in absorption. Nos. 9, 10 and 12 were made from the mortar and concrete, being used in the construction of a sewer at the time of the experiment. No. 11 was a section of concrete pipe furnished by the Lock Joint Pipe Co., and was about one year old. No. 13 was a tile used by the same company for lining their pipes with, when required by engineers. Nos. 14 and 15 were samples of salt-glazed vitrified pipe.

While admitting that these experiments are far from being complete and exhaustive, Mr. Rankin draws the following conclusions from them.

1. "That for similar materials, although there is considerable variation in the ratio, the abrasion in every case except No. 12 increases with the absorption, that gives a fair idea of the wearing qualities of the materials.

2. "The additional cost of lining a brick sewer is warranted, although the two per cent. requirement of the Newark specifications seems unnecessarily severe.

3. "The concrete sample compares favorably with paving brick and it would appear unnecessary to line a concrete sewer.

4. "Tile pipe is generally not as durable as concrete pipe."

The last two clauses are particularly noteworthy in connection with the subject under discussion, and are somewhat contrary to the belief commonly held by many people who cannot be accused of being prejudiced against concrete in any way.

Tests by Mr. C. C. Clarke tend to indicate that the best proportions to resist abrasive forces are 1 : 2 for Portland cement mortar. This fact might be made use of in plastering the inside of concrete sewers, as is sometimes done.

Mr. Hermann describes some investigations into the wearing power of some sewers in St. Louis. The grades of these sewers range from .2% to 2%. The vitrified clay pipes show no appreciable wear after thirty-five years use. These are usually laterals carrying small amounts of sewage, but carrying a considerable quantity of strong acids and scalding water. The vitrified brick sewers also show no appreciable wear but they have been only about twelve years in use. One course of square-edged vitrified bricks are used for the bottom quarter of the circular sewers and in those of other shapes are carried up six inches above the ordinary foul water flow.

The inverts of sewers built of common bricks begin to show some wear after about three years of service, and after about thirty-five years the first row of brick has nearly disappeared. The wear is found to vary greatly, in sewers of different size, shape and grade, and with the quality of the sewage and the hardness of the brick.

Mr. W. C. Parmeley considers that a more resisting surface can be got from concrete than from any but the hardest vitrified brick.

In Duluth, Minn., the grades of the sewers are exceptionally steep and it has been found impossible to keep sand and small stones out of the sewers. Concrete sewers have been proven to be more durable than brick. In one case on a very steep grade, granite flags were laid in cement mortar. Two years later the granite was found to be worn away, leaving ridges of mortar between the flags showing the concrete to be more durable than granite. Mr. T. J. McGillivray, city engineer of Duluth, says that he finds that the gravel and stones washed into the sewers in time of storms abrase the "skin" of the vitrified clay sewer pipes, which results in the speedy disintegration of the pipe. This is a somewhat unusual circumstance, as vitrified pipes are usually considered fairly hard and durable under almost every condition.

In the construction of a sewerage system at Louisville, Ky., all sewers were lined when the size and grade were such that a velocity of eight feet per second would be likely to be exceeded. In small circular sewers of twenty-four to thirty-six inches diameter the lining was vitrified pipe, while in larger sewers the bottom and sides were lined with vitrified bricks laid in cement mortar.

In the construction of the intercepting sewers in Toronto, brick was used in part, and brick lined concrete in the rest. The use of brick in this case seems to have been more due to the pressure brought on the City Council by the brick interests than from any belief in the superiority of brick as a material for sewers.

In view of the extra cost involved in the use of vitrified bricks and their doubtful efficacy, the use of vitrified brick lining for sewers appears to be doubtful economy. It is always advisable to examine the grade of a sewer and the consequent maximum velocity of the sewage before it is decided whether to line it or not. In case the maximum velocity exceeds about eight to ten feet per second, it would seem to be good practice to line the sewer.

General Suitability

There are two qualities which any material must possess before it can be successfully applied to sewer construction, that have not yet been taken up in detail. These are water-tightness and smoothness of surface.

Concrete is eminently fitted for sewers in that it is capable of being constructed with a very smooth surface, and all special construction necessitating the use of sharp angles and curves can be made perfectly true to shape, thus offering little resistance to the flow of sewage. This is of great advantage where there are many sharp turns in the sewer and the grade is slight.

In order that a sewer may fulfill the duties for which it was built, it must have such a form and be laid to such a grade, as to cause a sufficient velocity in the water to carry along any solid materials that may be in the sewage. Upon reference to literature on hydraulics, we find that a velocity of water in a pipe from two and one-half to three feet per second is necessary in order to cause such materials as sand, gravel, etc., to be carried along. According to Ogden, in his work entitled "Sewer Design," if a pipe has these velocities in it when flowing half full, it will have a self-cleansing velocity when only flowing partly full. Suppose that it is decided in designing a sewer that a velocity of three feet per second when the sewer is half full is the minimum allowable velocity. It is desired to find the minimum grade that will produce this velocity. For the sake of illustration the cross-section of the sewer shall be considered circular.

The formula most used in computing the velocity of water is Chezy's.

$V = C\sqrt{RS}$ where

V = velocity in feet per second.

R = hydraulic radius.

S = size of slope angle.

C = constant depending on the slope, shape of cross-section, and roughness of surface. C is usually determined from Kutter's formula:—

$$C = \frac{41.66 + \dfrac{1.811}{n} + \dfrac{.00281}{s}}{1 + \left(41.66 + \dfrac{.00281}{s}\right)\dfrac{n}{\sqrt{R}}}$$

where "n" is a coefficient of roughness depending on the roughness of the surface with which the water is in contact, the other symbols having the same significance as in Chezy's formula. Before proceeding any farther it is necessary to fix on the value of "n" to be used in the above formula. Merriman gives the following values for "n."

n = .011 for cement mortar.
n = .013 for good brick work.
n = .015 for unclean surfaces in sewers.

In Ogden's "Sewer Design" the following values are given:—

n = .011 for cement mortar and cement pipes well jointed and in good condition.
n = .012 for tough cement mortar.
n = .013 for well-laid brickwork.

In the design of the concrete sewers at Louisville, Ky., a coefficient of n = .013 was used. It would appear that for concrete sewers in fair condition a coefficient of n = .012 would be reasonable, while in brickwork a value of n = .015 would be all that could be expected. This difference in the values of the coefficients will have the effect of producing different results in determining the minimum grades in order to produce the minimum velocity in the two different types of sewers.

The minimum grades for pipes of various diameters, consistent with the afore-mentioned assumptions are given in the table below:

DIAMETER OF PIPE IN FEET	MINIMUM GRADE	
	CONCRETE n = .012	BRICK n = .015
2	.00150	.00260
3	.00085	.00140
4	.00055	.00092
5	.00042	.00065
6	.00034	.00053
7	.00027	.00043
8	.00022	.00037
10	.00017	.000275

TABLE No. 2

Of course these figures hold true for circular sewers flowing either half or full, but the principle involved is the same whatever be the shape of the cross section and the depth of water flowing through the sewer. That is, that concrete sewers can be laid on flatter grades than bricks for the same minimum velocity.

This table shows that in a case where the outlet has to be kept as high as possible while preserving a minimum grade in the sewer, a considerable saving in excavation might be effected by using a concrete sewer in preference to a brick one. Thus, for a five foot sewer the saving in grade would be .023 ft. per hundred feet. This in a mile of sewer would mean a saving in excavation at the end of the mile of

1.12 feet. The saving in the cost of a mile of excavation in rock would be (taking the cost of rock excavation as being \$3.00 per cubic yard) approximately \$1,900. This in a sewer several miles long would affect a considerable saving. For earth excavation, however, the saving would probably be not more than one-sixth of this amount. Also in low level sewers where the sewage has been pumped a reduction of the grade would mean a reduction in the height which the sewage has to be raised.

The difference in roughness of the interior surface of the two different types of sewer results also in a difference in their carrying capacity. This is shown very clearly by the accompanying curves. These show that for any particular diameter of pipe and grade, the concrete sewer has a much greater carrying capacity than the brick sewer. Although the cases here illustrated are very limited in their application, the sewers being supposed of circular cross section and to be flowing full, the fact remains that concrete sewers have a greater carrying capacity than brick sewers of the same size whatever be the shape of the cross section, or the condition of flow in the sewer. Some may not agree that there is as great difference as is found by using values of n = .012 and n = .015 for concrete and brick sewers respectively, but it is quite apparent that a higher value would be used for brick than for concrete sewers, and the values above-mentioned are about as good as can be obtained at this stage of our knowledge of the flow of water in pipes. In the foregoing computations the usual assumption has been made, that, so far as the hydraulics of the case are concerned, sewage is practically all water.

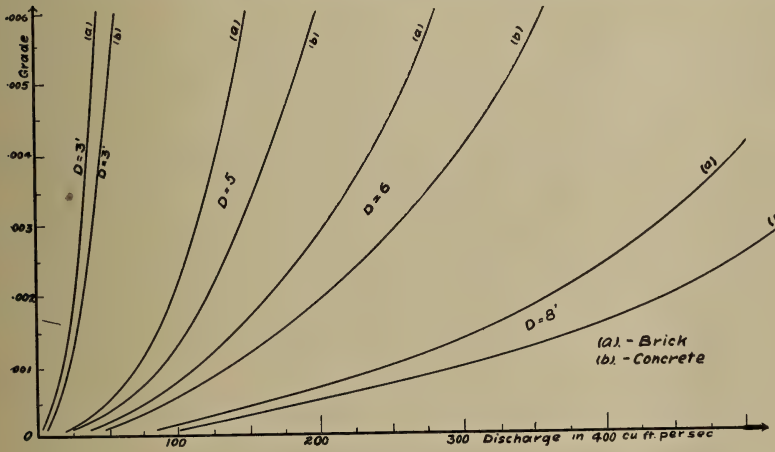

FIG. 1.

It has been frequently asserted that concrete not being an absolutely water-proof material in itself, concrete sewers would be defective in that they would be liable to admit ground water and also to allow the sewage to leak out, thus polluting the ground in the vicinity of the sewer. This is, apparently, erroneous, when one considers that there are numerous concrete pipe lines all over the country which convey water, sometimes under considerable heads, without undue leakage. This would seem to indicate that it is perfectly possible to make concrete waterproof.

It is scarcely necessary to mention the numerous different methods of water-proofing concrete here. These details can be learned upon reference to any work on concrete. However, the first essential of a waterproof sewer is a carefully graded and mixed concrete. A careful study of the aggregate to be used should be made and an effort should be made to have as dense a mixture of concrete as it is possible to obtain. Also, especial care should be taken in the mixing, placing and bonding of the concrete. If this is done an important step towards obtaining a waterproof sewer has been taken. Lime and fine clay have sometimes been used in waterproofing concrete sewers.

A concrete sewer was constructed in Denver beneath the level of the La Platte River. An effort was made to have the sewer waterproof in order to prevent seepage of the ground water. The contractor was allowed to adopt any means his fancy suggested for waterproofing the concrete, but he had to guarantee the sewer to be waterproof a year from the time of completion. The contractor used Toxement, a patented waterproofing compound, using three pounds for each sack of cement. Reliance was placed on the concrete mixture for obtaining a uniform distribution of the compound. A satisfactory result is said to have been obtained.

Preliminary to the construction of the Louisville sewerage system the commission in charge made some tests for finding the most impervious concrete. Concrete pipes were tested for about seven hours under a pressure of about fifteen pounds per square inch. The concrete used consisted of one part of cement to two parts of Ohio River sand to four parts of Ohio River gravel. Tests were made on plain concrete and on concrete containing lime, clay and various precentages of several waterproofing compounds. The best results were obtained by the use of four per cent. Medusa and four per cent. Toxement Waterproofing Compounds, the seepage in each case being zero. With the 1 : 2 : 4 concrete the seepage was 6.30 cubic in. per square inch of surface.

In a part of the construction of these same sewers a fine clayey moulding sand was used for ten per cent. of the sand 1 : 2 : 4 mix. The sand was thoroughly mixed with water and then mixed with the rest of the sand and the cement. As far as can be seen this method is satisfactory.

So far as the permeability of concrete sewers and their consequent liability to leakage is concerned, there seems to be little cause for alarm, provided reasonable care is used in the construction.

Stresses Due to External Pressure

In designing sewers it is usually customary to consider the sewer as having to sustain all the dead load of the fill over it and also all the live load that is likely to come on it when the amount of cover is less than four feet. When the amount of fill exceeds four feet the sewer is supposed to be capable of sustaining the weight of the fill and a certain percentage of the live load, this percentage varying from one hundred at four feet deep to zero at about fourteen feet, at which point the live load is supposed to cease to have any effect. These figures are only assumptions, although probably very reasonable ones, since it is difficult to arrive at any definite conclusions from theoretical considerations alone owing to the uncertain nature of earth pressures.

An empirical formula for determining the amount of pressure liable to come on the sewer from the dead and live loads runs as follows:—

Dead Load $= 83d - 2.54d^2$
Live Load $= 1000 + 3.72d^2 - 112d$
where d = depth of fill over sewer.

According to this formula the live load ceases to have any effect when the depth of fill exceeds about 15 feet.

In designing sewers considerable allowance has to be made for the uncertain stresses liable to be set up by irregular settlements of the foundations, and quite large factors of safety are usually considered necessary. A very complete analysis of the subject of stresses in circular sewers and culverts subjected to earth pressure is given by Prof. A. N. Talbot in a bulletin issued by the University of Illinois. In introducing the subject the professor says: "The stresses developed in rings and pipes subject to external pressure, are, of course, dependent upon the bending moments developed. As the exact load coming on the sewer and its distribution over the surface are difficult to determine, the bending moment is in general quite uncertain. The amount of load and its distribution over the surface, and therefore the bending moment on different parts of the ring depend upon a number of conditions, such as the nature of the earth used in filling, the method of bedding the pipe, the manner of tamping the earth at the side, the amount of lateral restraint or pressure of the earth, the conditions regarding moisture, etc." These conditions of loading may include:—

1. A concentrated load at the crown.
2. A vertical load distributed uniformly over the horizontal section.
3. A distributed vertical load together with a horizontal load distributed perpendicularly over the sides of the ring.
4. An oblique load, such as may prevail in a sewer trench, a slip of earth causing pressures to be set up in the sewer that are not provided for in any of the previous cases.

Mr. Talbot made a large number of tests on plain and reinforced concrete rings and pipes, comparing the results of these tests with those derived from formulae. An examination of his results shows the chief benefits to be derived from the reinforcing of concrete pipes would be in lessening the liability of sudden failure from shock and pressures not otherwise provided for, and in permitting the use of a thinner shell for the pipe. The reinforcement should also be taken into account in fixing on a proper factor of safety. The main lesson to be derived from his tests is, however, the advisability of providing a uniform bedding for the sewer and an evenly distributed, well-compacted, filling, in order that the pressures on the sewer may be distributed and not concentrated.

So far as the small number of tests made upon the relative strength of concrete and vitrified clay pipes admits of a conclusion the resistance of the pipes against outside compression varies to a great extent, even with pipes of the same size, and made of the same materials. However, the concrete pipes seem to give slightly higher average values than vitrified clay pipes.

Average results derived from experiments are not very conclusive, and since no sewer is stronger than its weakest length, sewer pipe of material with a fairly constant and uniform strength is preferred to one of higher average strength, but which on account of its brittleness, is more liable to sudden failure. This is one drawback to the use of vitrified clay pipes of large sizes. Their brittleness renders them liable to breakage due to careless handling or to sudden shocks from various causes.

Mr. Alex. Potter gave before the Boston Society of Civil Engineers a description of some of the difficulties encountered in the construction of about one hundered and fifty miles of vitrified pipe sewers in Newark, N.J. In this sewer system, twenty-four and twenty-six inch tile sewers were laid, some in wet trenches where they had to be supported by timber foundations. The discovery of the failure of a two-hundred foot section of twenty-four inch pipe led to an inspection of the entire system. It was found that in the cases of the larger sizes, a large number of the pipes were cracked, and in a few cases had completely collapsed. All these breakages were in rock trenches, or in places where broken stone or gravel foundations had been used. The pipes laid in quicksand or on timber foundations were found to be intact. Mr. Potter is of the opinion that no vitrified pipe larger than 20 inches diameter should be laid without a concrete foundation. The extra cost of the concrete foundation should be taken into account in estimating the relative cost of vitrified pipe sewers and those of other materials for sewers these sizes.

Tile pipe is now made in various sizes up to 42 inches in diameter, but the concensus of opinion among engineers seems to be that their use is inadvisable when a sewer of greater diameter than 20 inches is required. The ability to use steel reinforcement, either in pipes or monolithic construction, to take up the tensile stresses, would seem to be an important point in favor of the use of concrete for sizes of greater diameter than twenty inches.

In the construction of sewers in Richmond, Ind., vitrified tile pipe was used for sizes up to and including eighteen inches diameter, while concrete was used for sewers of from twenty inches to fifty-four inches in diameter. The twenty-inch pipe was not reinforced and was found to be unsatisfactory; the larger sizes were reinforced and gave good satisfaction.

The strength of the plain concrete pipes of small diameter does not seem to be much different than that of tile pipes of the same diameter, while for the larger sizes good design and proper construction is all that is required in order to obtain a thoroughly strong and reliable concrete sewer.

Comparative Costs

The relative costs of sewers of different materials in any particular case, depends largely on circumstances peculiar to that case, such as proximity to the source of manufacture. However, there are several general principles, which hold true in almost all circumstances, and are applicable to a greater or less extent under all conditions, which tend to make concrete sewers cheaper than brick ones of the same size. A brief discussion of these will now be made.

Within the past few years the price of brick has advanced about fifty per cent. while the price of cement has decreased about the same amount. The market price of broken stone and sand, while governed almost entirely by local conditions, has remained nearly constant.

About seventy-five per cent. of the weight of the entire masonry of brick sewers, that is, the bricks themselves, must be transported from the factory to the site of the work. A large cost is usually involved in freight and teaming charges. On the other hand in the case of a concrete sewer, frequently only about ten per cent. of the weight, i. e., the cement, has to be brought long distances, and since the quantity required is only slightly in excess of that required for brick masonry, the gain is still more apparent. The high cost of vitrified brick also tends to increase the cost of masonry structures.

Only skilled bricklayers can lay bricks for sewers, and skilled labor is expensive, while concrete can be laid by unskilled laborers.

Bricklayers have powerful unions, and a contractor is liable to be held up by a strike among his bricklayers, the possibility of which he has to allow for in his bid.

A brick wall must be built of sufficient thickness to contain the line of pressure near the middle third of the ring, in order to prevent cracking. This generally results in working the materials at a very low efficiency. For example, masonry that can safely withstand a pressure of from one to two thousand pounds per square inch is worked at a pressure rarely exceeding three hundred pounds per square inch, as to increase the unit pressure would produce rupture in the part cf the arch subjected to tension. Concrete has the advantage that it can be reinforced with steel. With steel reinforcement, the mass of the masonry may be cut down fifty per cent. and the materials comprising the structure may be worked at predetermined and properly ascertained efficiencies.

As shown before, a concrete sewer will carry a much greater volume of sewage than a brick sewer of the same size, laid on the same grade. Thus, when a given amount of sewage is to be carried, a smaller sized concrete sewer will suffice than would be required for a brick sewer. A concrete sewer six feet in diameter has nearly as great a carrying capacity as a brick sewer six and one-half feet in diameter.

Supposing in the two cases, the factors of thickness of the wall of the sewer, the cost of the material in each case to be the same, then the increased diameter will be responsible for an increase in the amount, and consequently in the cost of the material, of about five per cent., and for an increase in the amount of excavation necessary of about seven per cent.

From the above theoretical considerations we would suppose that brick sewers would probably be more expensive than concrete ones of the same carrying capacity. Upon examining cases where bids have been received for the construction of a sewer of concrete or brick, we find that the truth of these assumptions is borne out by practice. A notable instance of this is a concrete sewer constructed at Toledo, Ohio. Bids were called for a sewer to be of either brick, concrete block, monolithic concrete, or reinforced concrete construction. The contract was awarded to Breymann and O'Neil, of Toledo, on block construction according to the designs and patents of W. C. Parmeley, C.E. The prices for each section of the sewer and for each different type of construction were as shown in the accompanying table, being the lowest one for each of the types. No bids were received for a reinforced concrete sewer.

Diam. of sewer in ft.	Length in ft.	Concrete Block Construction				Prices Bid Per Lineal Foot				
		Thickness in.	Vol. in cw. ft. p.l.f.	Transverse steel		Concrete Blocks	Monolithic Concrete		Brick	
				Size of rods	lbs. Total					
72	4342	5	8.4	9–16″	18.2	$17.70	8	$13.00	13	$12.75
66	2642	4½	7.0	7–16″	13.8	8.50	7	11.00	9	9.10
52	965	4	5.0	7–16″	10.5	6.25	6	7.00	9	6.85
48	980	4	4.76	3–8″	6.8	6.00	6	7.00	9	6.36
42	359	3½	3.65	3–8″	6.0	4.50	5½	6.00	9	5.76
36	321	3	2.68	3–8″	5.3	4.00	5½	6.00	9	5.00
30	714	2½	1.86	3–8″	4.5	3.00	4½	4.00	9	3.70
24	827	2½	1.50	5–16″	2.5	2.10	3½	2.50	9	2.20

TABLE No. 3.

Many cities have discontinued the use of brick in sewers on account of the heavy cost. Among these are Boston, Mass., and Hamilton, Ont.

In the construction of the high level intercepting sewer in Toronto, certain sections of it were built of concrete lined with brick, and others of brick alone. In the sections where concrete was used the economy was very marked as shown by the bids received for the two different types of construction. For instance, in Section No. 3 (Jarvis St. to the Don) the lowest bid received for a brick sewer was $33.13 per lineal foot, while for a concrete sewer the lowest bid was $19.97 per lineal foot. By the use of concrete alone a saving of $84,500 would have been effected in this section. As it was brick-lined concrete was used at a saving of $72,000 compared to the cost of a similar brick sewer.

The cost of concrete pipes varies greatly under differing conditions, but in general they are cheaper than vitrified tile pipes of the same size. At Denver, Col., seven thousand feet of 38-inch continuous concrete pipe was made by the Ransome process. The cost of the pipe was $1.35 to $1.50 per foot, with cement at $3.75 per barrel, gravel $1.25 per yard and wages $1.75 to $2.00 per day. The cost of the same size vitrified pipe would have been about $3.00 per foot in place.

In 1894 at Scarborough-on-the-Hudson 900 feet of 24-inch pipe and a mile of 10-inch pipe were built by the Chenoweth process at a cost of 95 cents per foot for the larger size and 23 cents for the smaller, as compared with 97 cents and 30 cents for the corresponding sizes of vitrified tile.

At Despatch, N.Y., concrete pipe made by the continuous process cost as follows; for 8-inch pipe about 6 1-3 cents per lineal foot, 300 feet being constructed per day, for 12-inch pipe, 10¼ cents per foot, about 400 feet being constructed per day. Vitrified pipe under the same circumstances would have cost 17½ cents per foot for the 8-inch and 35 cents per foot for the 12-inch pipe. As can be noted, these prices for the tile pipe are lower than they can be usually obtained at in most places.

The following table shows the thickness of cement pipe made by the Miracle Company with their estimate of the quantities and

Size inches	Thickness, in.	Cubic Feet of Sand per Pipe	Cost of Labor	Total Cost Per Foot
6	1	.324	$0.08	$0.050
8	1	.452	0.08	0.065
10	1⅜	.830	0.10	0.115
12	1½	1.100	0.10	0.155
15	1½	1.400	0.11	0.192
18	1⅝	1.840	0.13	0.237
20	1¾	1.950	0.13	0.255
24	2	2.750	0.15	0.343
30	2½	3.700	0.17	0.443
36	3	4.900	0.20	0.575

TABLE No. 4

cost. These figures were computed for a 1 : 3 mixture, and sand costing 75 cents per cubic yard and cement $2.00 per barrel.

The cost of cement and sand varies greatly in different localities, however $2.00 per barrel is a very common price for cement.

In general, concrete sewers seem to be cheaper than those of other materials, in many cases by a considerable amount, and very seldom, if ever, are they more expensive than those of brick or vitrified tile construction.

STEEL RAIL FAILURES

By H. Hyatt, B.A.Sc.

Part I.

The rail of rolled steel as it is used to-day in America for the carrying of railway traffic is a comparatively modern contrivance, although rail "ways" date back at least as far as the middle of the sixteenth century, when wooden planks, fastened end to end on logs of wood, were employed in the mineral districts of England as rails over which to pull wagons of coal from the mines to the waterways. In following the evolution of the rail, from this primitive structure as an origin, we find next that these wooden rails were covered with thin strips of iron in order to lengthen their serviceable life. This expedient caused excessive wear on the wooden wagon rollers, and led to iron wheels, which are recorded in 1734. With subsequent increase in traffic, however, the iron sheathing evidently did not prove of sufficient strength to carry the heavily loaded cars without buckling, and the plan was tried of making the rails of iron throughout. A lot of rails which were cast in 1767 were 3 feet long by 4 inches wide, and on the innerside was a perpendicular flange 3 inches high. These were laid flat, and are distinguished as Plate Rails.

The next important development was the Edge Rail, which was practically the plate rail set on edge, but was of necessity much stronger against bending. Subsequent developments were, the gradual but complete abandonment of the plate rail, increases in length, improvements in manufacture, and the substitution of wrought iron for cast iron, especially the latter, after an improved method of rolling was patented in 1820. Previous to this a species of socket joint had been tried, but, on account of frequent breakage, had been considered unsatisfactory and abandoned, and the joints were made in the cast iron chairs, which have since come into general use on English railways.

The advent and gradual development of the steam engine made possibilities of greater loads, longer hauls, and faster travel, and henceforth rails become of more importance than they had previously been.

In 1830 Stevens designed the tee rail, having a flat base, which was secured to the ties by hook-headed spikes without chairs, and which has since been the type of design employed in America. In 1837 Locke designed the double-headed rail, which was an easily rolled rail, and, being reversible, was two rails in one. But as it was laid in cast iron chairs, the lower head was damaged by the hammering of the traffic, and was thus rendered useless as a running surface. Later the bull-headed rail was designed, in which the lower table was made of smaller size and to serve as a support only, not as a running surface. This rail became the basis of the rail which is now almost universally adopted in England.

Returning to the tee rail in America, we find that about 1857 the prevailing shape of rails was that which was known as the pear head (Fig. 1). This was the form of the cross-section of the wrought iron rail rolled by English mills for export—a cross-section adopted to prevent the sides of the head from breaking down. The wrought iron rail served its purpose as long as wheel loads were not excessive nor speeds too high, but railroad progress seemed to have about reached its limit during the decade between 1860 and 1870. Further progress called for higher speeds and greater loads, but the wrought iron rails did not prove strong enough to withstand the weights imposed and the shocks incidental to high speeds.

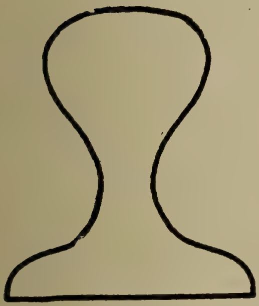

Figure 1.
84-lb. Wrought Iron Rail Section.
In use about 1857.

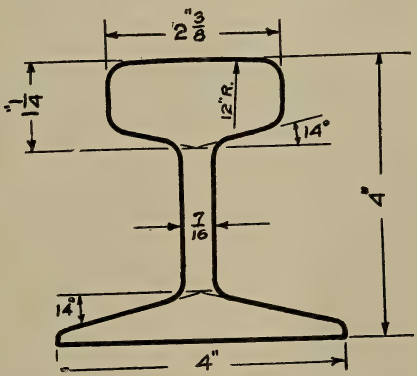

Figure 2.
53-lb. Steel Rail Section—Welch
Percentage of Area in
Head 45
Web 20
Base 35

In the meantime, however, Bessemer had discovered his process of steel manufacture, in 1858, and in the year 1867, at their Johnstown works, the Cambria Iron Company made the first commercial rolling of steel rails in America. These were rolled for the Pennsylvania Railroad Company from ingots made by the Pennsylvania Steel Co., at Steelton. This marks the beginning of the American steel rail, as it is employed at the present time. To quote Chas. B. Dudley from his presidential address to the American Society of Testing Materials, in 1908:

"Bessemer steel, the outgrowth of an attempt to make wrought iron cheaply, came just at a time when the wrought iron was beginning to demonstrate its unfitness to stand the pounding of the larger locomotives of the day. It is perhaps not too much to say that the Bessemer steel rail has made the modern railroad possible, and that without it or its equivalent, the world's development would be half a century behind its present advanced position."

The earliest steel rails very closely followed the sections previously designed for wrought iron, but Ashbel Welch, who later became a president of the American Society of Civil Engineers, made a radical departure from these when he designed his 53-pound section (Fig. 2). Rails of this section showed their advantage in that they outlived heavier steel rails of the older type, and also in economy of material. The Welch section was used to a considerable extent, and for some years determined the type of rail used in America. But, in 1874, Chanute, then chief engineer of the Erie Railroad, brought out the section shown in Fig. 3. The essential departure from the Welch section is in the larger percentage of metal in the head, the straight flaring sides, and the thin web and flanges. The Chanute section became a basis for a number of other sections, sections with larger heads, particularly in the vertical dimension, with both perpendicular and inclined sides, with webs and flanges decreased in size for the purpose of getting metal into the head where the wear came.

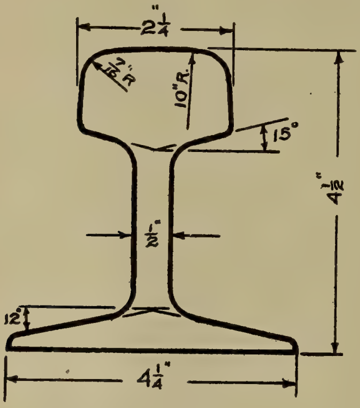

Figure 3.
Chanute Rail Section
Designed 1874
Percentage of Area in
Head 47
Web 20
Base 33

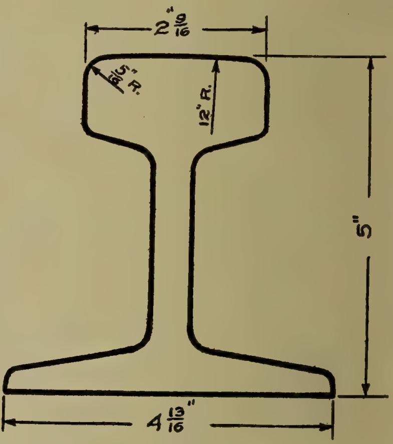

Figure 4.
80-lb. Rail Section—Dudley
Designed 1883
Percentage of Area in
Head 45
Web 20
Base 35

But it became evident with experience that these rails with the small webs and flanges and the heavy heads did not wear as well as the lighter rails rolled to the Welch section, and it was suspected by some that the fault lay in the design rather than in the chemical composition or the mill practice. A new and important departure from the then current practice was made in 1883 by P. H. Dudley, of the New York Central, who designed an 80-pound rail, which had a broad and shallow head in place of the narrow and deep head of the Chanute section (Fig. 4).

Since this period much has been said and done regarding steel rails. The year 1887 became the record year in both rail production and new track construction, about 13,000 miles of new track being built in the United States, and the production of steel rails amounting to over 2,300,000 tons, many of the larger systems became firmly established, problems of track maintenance began to receive more attention, and hence more attention was given to rails in an effort to make their employment as efficient as possible.

There have been a number of causes which have tended to complicate rail problems. The changes in the methods of transportation during the past twenty years, the increases in the sizes of both locomotives and cars, with the consequent increase in wheel loads, and in the strains produced, have made new demands upon railroad tracks, and especially upon the rail, as the most important element of the track. The average speed of trains has been largely increased; the average wheel loads of cars have increased 75 per cent.; and on some of the larger and more important railroads, the volume of traffic has increased at least 300 per cent., and perhaps more. The manner in which these changes have been met by increased weights per yard of rails, the modifications which have been effected in the Bessemer process of steel manufacture, the almost continual controversy which has existed between the steel manufacturers and the railroads, these and other items have all gone together to produce the modern steel rail problem.

Briefly stated, the problem is this: That, notwithstanding large and supposedly sufficient increases in the weight of rails, to correspond with the increases in traffic, speed, and wheel loads, the rails have not proved to be capable of carrying the traffic. In other words, the rails have failed, and their failure during service in the tracks is liable to be, and very frequently is, productive not only of serious financial loss to the railroad companies, but also of loss of life and serious injury to patrons and employees.

It might be supposed that with the advance of knowledge on the subject of rail design, and with the use of modern improvements in the art of steel manufacture, these failures would become less frequent as time went on. But for some reason or other this has not been the case.- We are not able to give a continuous series of figures to prove this conclusively, but the following paragraph, selected from many that are equally convincing, will remove doubt to a certain extent.

"The opinion is sometimes expressed that broken rails are not a cause of serious danger to trains. Any who may hold such an opinion will be interested to read the official report on railway accidents for the quarter ending September 30th, 1907. We there learn of a failure of a 100-pound rail, in service 9 years, which cracked between the head of the rail and the web. Four passengers and one trainman were killed and 13 injured. Another case is recorded where a broken rail derailed a train running fifty miles per hour on a straight line, injuring thirty-two persons and doing $63,000 damage to the rolling stock. The break was due to an inferior defect in the rail. We can quote, however, statistics which are even more convincing than isolated cases. On October 1st last, J. Kruttschnitt, of the Committee on Standard Rail and Wheel Sections of the American Railway Association, in a report to the association said: 'Roads covering a mileage of 159,351 miles report 24,023 broken rails in 1905, and 28,478 in 1906, an increase of 18 per cent.; but in 1905 there were 4,576 breaks attributed to piping, while in 1906 there were 6379, an increase of 40 per cent in the breakages of piped rails. These breaks caused the death or injury of 65 persons in 1905 and of 339 in 1906, an increase of 420 per cent.' This is proof positive that broken rails do constitute a danger to the traveling public, and that piped rails causing inferior flaws are particularly dangerous."[1]

"Definite figures concerning rail fractures which seem to be the most extensive ever published, are given by the New York State Railroad Commission, in a bulletin issued a few days ago. They are contained in tables showing the total number of rail breaks that occurred on the principal steam railways in New York State during the winter months, January to March, inclusive, and showing how they are distributed as to size of rail and date of rolling. The totals show not only a surprisingly large number of fractures, but also a striking increase during the year just past, as exhibited in the following summary, which we have compiled from the commission's figures:"[2]

"No candid mind can view the present steel rail situation, and not be impressed with the thought, that the steel railroad rail, or, perhaps more comprehensively the railroad track of today, is called upon to justify itself in the eyes of the public. . . . . It is plain, we think, that modifications at some point, and possibly at many points, are essential, in order that the new conditions may be successfully met. The startling record of rail breakages, which has characterized the past two or three years, the rapid wear, and the almost appalling deterioration, due to the crushing and flattening of rails in track, have produced an outcry against the steel rail, which, seconded by the technical press, has culminated during the past two years, in a charge of criminal negligence on the part of those engaged in the manufacture of this great essential of railroad operation. No one at all conversant with the situation can maintain that the subject is not a pressing one, and I am sure that all will agree that there is necessity for calm, cool, and dispassionate consideration of the various elements involved in the problem."[1]

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[1] Engineering News—V. 59—pp. 105.

[2] Fngineering News—V. 57—p.p. 493.

These few examples serve the purpose of showing the importance that is attributed to the subject by the technical press and those engineers and railroad officials directly concerned, and also gives a fair, although incomplete, idea of the number of failures which occur.

SUMMARY OF RAIL FRACTURES ON THE PRINCIPAL STEAM RAILWAYS OF NEW YORK STATE, FOR JANUARY, FEBRUARY AND MARCH, 1905, 1906, AND 1907

NAME OF RAILWAY	Miles of Main Track in New York State*	1905		1906		1907	
		No. of Fractures	No. per Mile of Main Track	No. of Fractures	No. per Mile of Main Track	No. of Fractures	No. per Mile of Main Track
Delaware & Hudson	857	60	.07	60	.07	93	.11
Lehigh Valley	807	125	.15	50	.06	103	.13
Rutland	171	10	.06	7	.04	20	.12
N.Y., N.H. & H.	160	10	.06	2	.01	29	1.80
B. & M.	146	34	.23	7	.05	5	.03
B. R. & T.	203	27	.13	4	.02	256	1.32
N.Y., O. & W.	526	...	...	24	.05	.05	.02
Pennsylvania	332	140	.42	186	.56	205	62
Lake Shore	158	227	1.44	34	.22	505	.32
N.Y.C. & H.R.	4183	469	.16	288	.07	1244	.30
Erie	1301	76‡	.06	142‡	.11	429‡	33
D.L. & W.	630	153	.24	22	.03	115	18
Totals	9474	1331	0.14	826	0.09	3014	0.33

*Mileage from 1905 Report of State Railroad Commission.
‡Incomplete.

For the purposes of this paper the consideration of these failures can best be done by a classification of the causes to which they have been ascribed, and by a demonstration, chiefly through quoting various authorities, of their relative importance, together with some notes on the various remedies which have been proposed and adopted.

The causes to which rail failures have been attributed are considerable in number, some authorities emphasizing one, some another, while others, and these are in the majority, consider that several causes have acted together to produce failure.

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[1] Chas. B. Dudley—Proc. A.S.T.M.—V. 8—pp. 19.

Classification is not in every respect advisable on account of the intimate relation existing between causes of two or more classes, but it is the only practical method of dealing with them, and hence we arrange them into four groups, as follows:

1. Design of the rail cross-section.
2. Chemical composition of the steel.
3. Manufacture of the steel and rolling of the rail.
4. Roadbed conditions and effects of the rolling stock.

Each group will be considered separately in the above order, as far as is practical.

Design of the Rail Cross-Section.

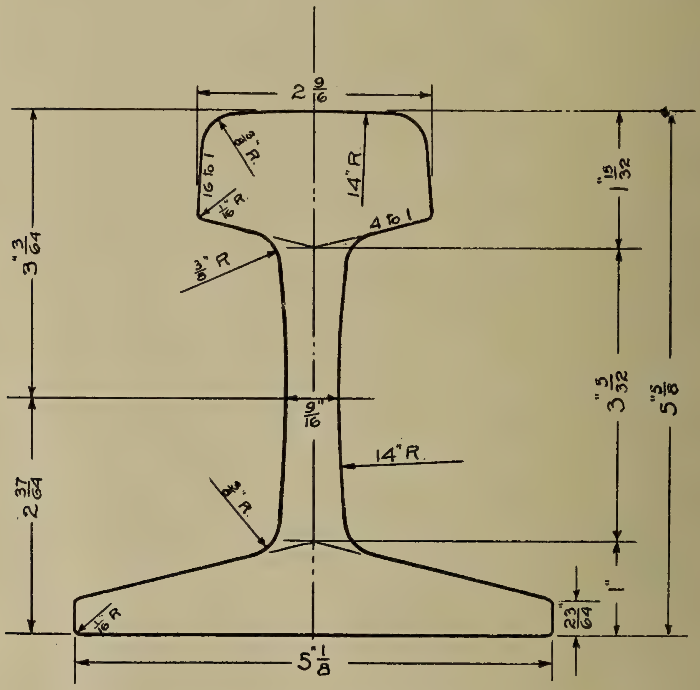
That the design of the cross-section of rails **may** be a factor, and an important one, in the abnormal number of breakages which have occurred, is not to be doubted, although, whether it actually is or not, is a much disputed question. There are, however, four ways in which it may enter into the problem. First, the section in use may be an essentially incorrect one, and unsuitable for the service for which it is intended. Second, the area and weight of the section may not be sufficiently great to withstand the wheel loads and other stress-producers that are present during service. Third, the section may be of such a form that the steel cannot be properly rolled. Fourth, the present section may be essentially correct in form, but nevertheless require improvements in its details.

With regard to the first item, namely, that the section in use may be essentially an incorrect one, there is not a great deal to be said. Comparison of the rail failure statistics of Great Britain with those of America will at once show that the advantage lies with Great Britain to a considerable extent. There is a possibility that this advantage is due to the different cross-section of rail in use. The bull-headed rail is a more simple section to roll and can therefore be better made. The similarity of the head and base produces a balanced rail, and the total absence of thin edges and of corners gives a section in which, during the process of rolling, the temperature may fall uniformly, thus doing away with a considerable portion of internal stress, and giving an opportunity to work the entire rail to a lower temperature. Such working produces a steel of finer structure and of a general soundness which cannot be had if the steel retains a large portion of its heat when working is concluded. But any proposition to adopt the British rail system in America must be considered an impractical one, even though it were conclusively proven that the bull-headed rail is superior to the tee rail. The question of cost will prohibit such a change for at least some years to come. Whether cost is the only consideration which prevents such a change of cross-section as this is a question which is rarely if ever discussed, authorities generally taking it for granted that improvement is to be sought in other directions. R. W. Hunt, during a discussion on the question of sections, in 1907, made the statement that, "We are now at a point where I think we ought first to make a radical departure in the design of the heavier sections." But what this radical departure was to be is not stated.

Concerning the second item mentioned, that the area and weight of the section may not be sufficiently great to withstand the wheel loads and other stress-producers that occur in service. Concerning this much has been said and written. The railroads maintain that the increase in the weight of the rail, that has been made to meet increases in the wheel loads, traffic and speed, have been all that is required, but the rail manufacturer maintains the contrary. There is room for argument on this question on account of the fact that it is extremely difficult to show as a matter of figures either one way or the other as to whether the steel is of sufficient area to withstand the stresses or not. It is doubtful whether the rail should be considered as a beam supported at each end or as a girder with three supports. It is doubtful as to the impact allowance which should be made, on account of the speed of the trains and also on account of a number of other shocks to which a rail is liable during the passage over it of a heavy locomotive, followed by a heavy train of cars. Under these conditions it is more a matter of opinion and experience than anything else as to whether the rails in present use are sufficiently heavy. It is known that locomotive and car weights have greatly increased, that traffic is much heavier now than a few years ago, and that speeds have also increased to a considerable extent. The question then remains, have the corresponding increases in rail weights been great enough? The only answer we can give is to offer the following opinions for consideration.

Regardin this question of increasing the cross-sectional area of rails, Chas B. Dudley, of the Pennsylvania Railroad, spoke thus: "Has the increase been sufficient? Is not a rail weighing 110, 120, or even 140 pounds essential to meet the strains produced by the changed conditions? Upon this point is possible to say that most careful studies have been made, using the best obtainable data, and making allowances for what is more or less unknown and uncertain, and that these studies indicate that the weight of rail, to carry the increased wheel loads, has been increased more rapidly than the wheel loads, and that the actual strain, with the heavier wheel loads, is no greater than was the case in the lighter rails under the lighter wheel loads formerly employed. It may be added that if 12,500 pounds per square inch is assumed as a safe working stress for such steel as rails are made of, the present 85 and 100-pound rail show stress well within this limit, even under a static wheel load of 30,000 pounds, with a dynamic augment of 60 per cent. of the static load. If these studies can be trusted, therefore, it would seem that so far as the weight of rail is concerned, the railroads have done all that could be reasonably required to meet the changed conditions with which we are dealing."

E. F. Kenney, of the Cambria Steel Company, is, on the contrary, directly opposed to this conclusion, as is evident from the following expression of his opinion: "With the coming of the extremely heavy wheel loads and the greater tonnage and speed which have been adopted in the last few years, the stress and shock in the rail have increased. Moreover, the difficulty of keeping up good track has increased, and since the condition of the roadbed as to line, surface, etc., has an immediate effect on the stresses and shock in the rail, these elements- combined with the direct effect on the rail from the increased loads and speed, have so increased the rail's work, that the factor of safety is about used up, and the great number of failures to-day shows that we are on the ragged edge. While the weight of the rails



AMERICAN RAILWAY ASSOCIATION
90-lb. RAIL, SECTION "A"

Moment of Inertia—38.70
Section Modulus
of Head—12.56
of Base—15.23

Total area 8.82 sq. in.
Head 3.20 sq. in.—36.2 p.c.
Web 2.12 sq. in.—24.0 p.c.
Base 3.50 sq. in.—39.8 p.c.

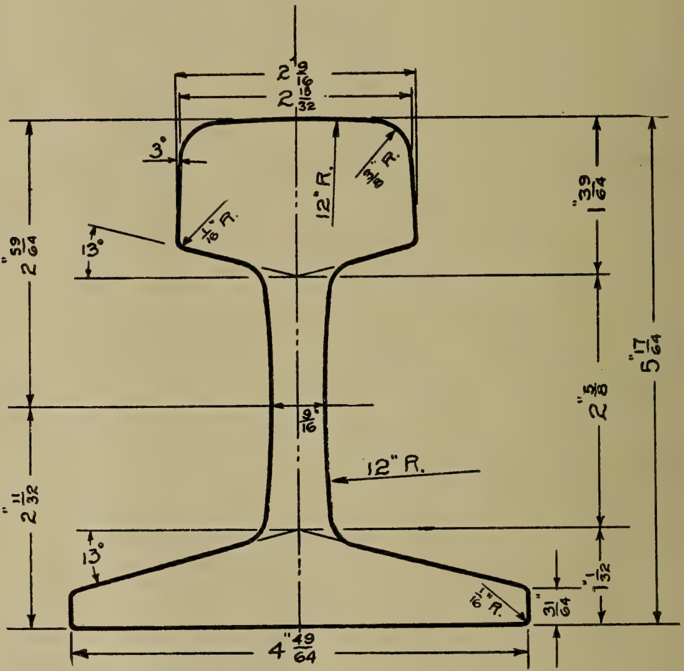
has been increased from time to time, the increase has not, particularly in the past fifteen years, been in proportion to the increase of the loads, tonnage, and speed. . . . . In almost any engineering structure, an increase in the load and stress is met by the engineer by an increase in resistance, by means of greater sections and stronger members; but there seems to be very strong opposition to an increase in the amount of steel in the rail. . . . . . It seems quite probable that the adoption of much heavier rail sections than used to-day would be distinctly an economy because of the reduction of cost of maintaining the track. Aside from this it would be unquestionably an advance on the side of safety."

The rail committee of the Canadian Society of Civil Engineers, before the 1911 annual meeting of the society, reported concerning the question in part as follows: "The question has sometimes been asked, has the weight of the rail section increased as rapidly as the wheel loading? To this may be answered, Yes. In the days when a 60-pound rail section was a common standard an engine axle loading of 24,000 pounds was not infrequent; this loading produced a tension in the rail, under the conditions of column three of the table, of 13,440 pounds per square inch, as compared with 12,842 pounds per square inch for a 100-pound rail under an axle loading of 50,000 pounds." The conditions to which reference is made are a 100 per cent. allowance for impact and the consideration of the rail as a continuous girder resting on three ties, the central one of which is unstable.

The Rail Committee of the American Railway Engineering and Maintenance of Way Association in 1910 reported in part as follows: "The rail manufacturers have claimed that the heavy wheel loads might crush down the head by reason of overloading or overstressing the metal without the presence of any internal defect causing the failure. In the reports available every case of crushed head, when the rail was cut open, shows that it was accompanied by an internal defect, and it should have been classed as a split rather than a crushed head. It was supposed that a crushed head might be considered the fault of the railroad company, while the split head, full of seams and cavities, which we call pipes, would be clearly the fault of the manufacturer."

The third way in which the section may be a factor in the abnormal number of failures is that it may be of such a form that the steel cannot be properly rolled. That the form of the section is productive of a poorer steel than might with other sections be the case is a point which is granted by the greater number of writers on the subject. The difficulty lies in the uneven distribution of metal through the section. The depth and width of the head, as compared with the thickness of both the flange and the web are so much the greater that, during the process of rolling, the flange and web become cool and unrollable before the head, and hence when rolling is discontinued the head of the rail is excessively hot. As is well known to every one acquainted with steel working, excessive temperature at the conclusion of rolling, is productive of a steel which is crystalline and generaly unsound, and, in addition to this, the variety of rates of cooling throughout the cross-section gives rise to a considerable amount of internal stress in the finished rail. The latest designs of rail call for an approximately equal percentage of metal in both head and flange, but the flange being wider than the head the same trouble continues, although perhaps in lesser degree. Concerning this portion of the subject we quote the following from Engineering, Vol. 84:

"High finishing temperatures are necessary, owing to the particular form of section of American rails. The heavy head, thin web, wide and thin base necessitate high finishing temperatures, otherwise it would be impossible to roll the bottom flange. This perhaps is the soundest of all the excuses advanced by the steel companies. The section should be of such form that the process of rolling and working of the material may be carried



AMERICAN RAILWAY ASSOCIATION
90-lb. RAIL, SECTION "B"

Moment of Inertia—32.30
Section Modulus
of Head—11.45
of Base—19.21

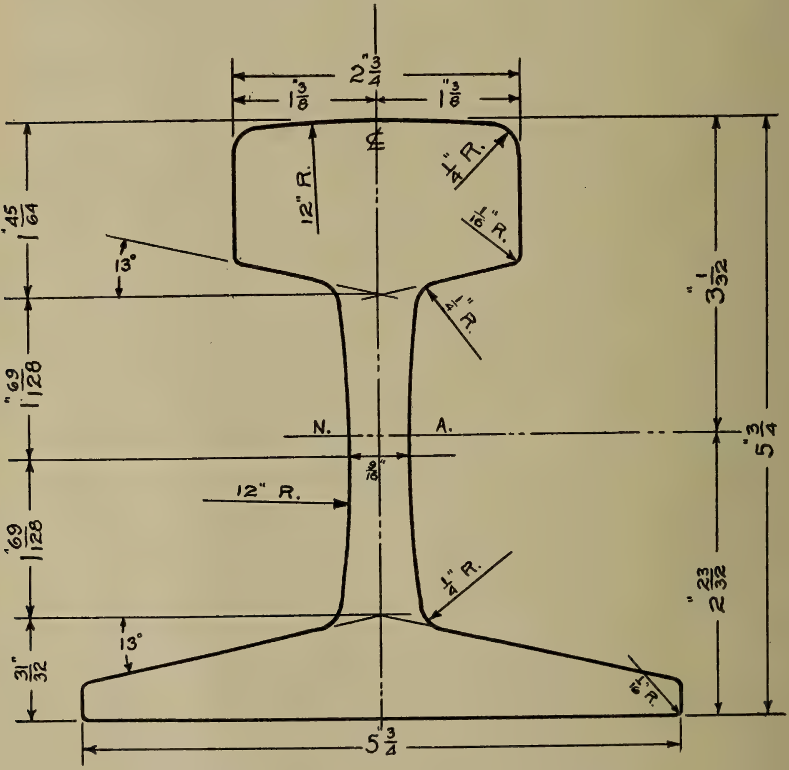
Total area 8.87 sq. in.
Head 3.56 sq. in.—40.1 p.c.
Web 1.70 sq. in.—19.2 p.c.
Base 3.61 sq. in.—40.7 p.c.

on in the manner best calculated to provide a good wearing rail."

W. R. Webster expresses the following opinion on the subject of the section with regard to rolling difficulties: "The sections now in use make it almost impossible to continue the work of rolling on the head to a low enough temperature to produce the fine-grained structure desired. . . . . The trouble is due to the large mass of metal in the head carrying the heat so much longer than the thin metal in the flanges, thus preventing the work of rolling on the head at sufficiently low temperature to break up the coarse grain and produce the tough, good-wearing rails desired. . . . . It has been the invariable experience in changing from a light to a heavy section, in any class of rolled steel, that difficulties have been made in the methods of rolling, in order to get as good structure in the heavier sections as was formerly obtained in the lighter sections. In ordinary sections, other than rails, it was a comparatively easy matter to overcome the trouble and get a good structure; but the thin flange of the rail, and the higher carbons called for in the heavier sections, further complicate matters. If a rail with the same width of head as the present American Society Civil Engineers' 100-pound rail is required, the head will have to be made thicker, and the radius under the head larger in order to prevent the sides of the head from shearing or breaking off as at present, and more metal put in the web and flange in order to carry the heat, thus allowing the head to be finished at the proper low temperature. This would mean a rail of about 120 pounds to 125 pounds per yard. I believe we are coming to heavier rails before we get rid of our present troubles."

There is not much doubt that the tee section in its present form presents difficulty in rolling. The difficulty can be overcome in some measure by placing as much of the metal in the base as in the head, and, since about 1885, when there was at least one section with 52 per cent. of the metal in the head as compared with 30 per cent. in the flanges, there has been a return to more of a balanced rail. Indeed the latest 85-pound section of the Canadian Pacific Railway has 41.02 per cent. of the metal in the base with 36.77 per cent. in the head, but this latter proportion was not so designed merely to overcome rolling difficulties. The balancing of the head and flange, however, is not the only thing that is required to simplify the rolling, as the thinness of the flange, as compared with the thickness of the head presents the same difficulty. This latter cannot be entirely overcome so long as the present form of section is employed. W. C. Cushing, chief engineer of the Pennsylvania Railroad, has not long since come to the conclusion, "That the new rail sections have not yet produced better quality of metal, where this has been sought by a better proportional distribution of material in head, web, and base, with a view to improving rolling conditions." And to the Rail Committee, who reported to the American Railway Engineering and Maintenance of Way Association, in 1911, it seems "that the design of the rail section is not the main cure for poor material."

The fourth item is that the section in use may be essentially correct in general form, but requires improvements in its details. In addition to those details of the cross-section already considered there is one other, to which reference should be made in considering rail failures, and that is the size and shape of the rail head as considered apart from the overcoming of the rolling difficulties. In designing the head of the rail there are two other items to be considered besides rolling difficulties, and they are, first, the strength of the rail as a girder for the sustaining of the wheel loads, and, second, the quantity of metal that is available in the vicinity of that part of the section where all the actual wear comes during service in track.



AMERICAN SOCIETY OF CIVIL ENGINEERS
100-lb. RAIL SECTION

Total area—9.82 sq. in.
Head 4.13 sq. in.—42 p.c.
Web 2.06 sq. in.—21 p.c.
Base 3.63 sq. in.—37 p.c.

Moment of Inertia—43.80
Section Modulus
of Head—14.85
of Base—15.64

In those cases where the girder action of the rail is assumed to be the more important the rail head has been made wide and shallow, whereas in those cases where the wear of the rail by the wheel treads is considered the more important the head is made narrow and deep. Both varieties of section are in common use, but the majority of writers favor the deep-headed rail. The case appears to be well represented by E. F. Kenny in the following words: "The desirability of stiff track is so well known and understood that some of the engineers working on the problem have shown a disposition to get the extreme value of stiffness that is possible with the amount of metal they are willing to use. This unquestionably makes better riding track and reduces the cost of maintenance, but they seem to forget in this hunt for stiffness that in disposing their metal so as to get the maximum moment of inertia, they are crippling the section in its details. Now, over 90 per cent. of the rails which fail do not fail as girders, but in their details; the split heads and broken bases are in no case the result of girder action. Regarding the split head, which is the type of failure probably causing more trouble than all the others combined, the following may be instructive: . . . . Road A uses a deep-headed rail, while B and C use a shallow-headed rail. The number of 100-pound rails removed from track in one year per 1,000 tons rolled is 0.66 for road A, and 12.59 for road C. The number of 85-pound rails removed from track in one year per 1,000 tons rolled is 0.59 for road A, 6.02 for road B, and 8.08 for road C. . . . . . Of the failures on the last named roads 90 per cent. were in the head, i.e., splitting, often spoken of as piping, while this type of failure was almost unknown on road A, with the deep headed rail. The shallow head is an element of weakness, which must be avoided if we are to escape this type of failure, and the necessary stiffness should be provided, not by spreading the metal out so thin as to weaken the head and base of the rail, but by the addition of enough metal to furnish the required girder strength without weakening the section in its details."

Ed. Note.—The second part of this article, dealing with roadbed conditions, rolling of steel, and chemical composition, will appear in the July issue.

The frequency with which some of our graduates' names appear has attracted the eye of a School man, who takes live and consistent interest in School affairs. He calls to our attention the fact that in the latest addition of the calendar the name Johnston appears fourteen times in the list of graduates. The name Campbell has thirteen adherents. There are twelve Smiths, twelve Browns, ten Wilsons, nine Stewarts, eight Rosses, and seven each by the name of Young, Robertson and Moore.

BIOGRAPHY

Mr. G. H. Duggan

One of the three men who comprised the graduating class of 1883 is Mr. G. H. Duggan, of Montreal. Born in Toronto in September, '62, instructed in Upper Canada College, from which he matriculated in 1879, Mr. Duggan entered the School of Practical Science in Engineering, the only then existing course, in 1880. The calendars of '81, '82 and '83 record Mr. Duggan's name as the winner of the first prize in Engineering in his first, second and graduating years respectively. It may be stated for the information of younger graduates that the course then comprised only three years.

For the session '83 and '84 Mr. Duggan was a member of the teaching staff of the School as Fellow in Engineering. Leaving the institution early in '84, he engaged as topographer on location, Mountain Division of the Canadian Pacific Railway, at Kicking Horse Pass, and later in the year he was in the designing office of the Canadian Pacific Railway at construction headquarters. In 1885 he was in charge of brick work in Field, Selkirk Range, and later of grading the summit of Gold Range, of the same mountain division.

While with the Canadian Pacific Railway he was connected with the construction of all large wooden bridges on Kicking Horse Division, the east slope of Selkirks, including Stoney, Surprise, Mountain and Raspberry Creeks, and the two crossings of the Columbia River.

Severing his connection with the Canadian Pacific Railway, in December, 1885, he engaged with the Dominion Bridge Co., first as draftsman, two years later as chief draftsman, and in 1891 as chief engineer, retaining the latter position for eleven years, during which connection with that company most of the important structures built by them were constructed, including the St. Lawrence River bridges at Lachine, Coteau and Montreal; the Interprovincial at Ottawa; bridges at Sault Ste. Marie, Grand Narrows, Fredericton, Bout de L'Ile; the hydraulic lift lock at Peterboro; the movable dam and regulating gates at Sault Ste. Marie, and other structures aggregating about 400,000 tons.

In February, 1902, Mr. Duggan engaged with the Dominion Iron and Steel Company and the Dominion Coal Company, as assistant to president on construction. In 1903 he was appointed third vice-president of these organizations. From 1904 until February of 1910 he was second vice-president and general manager of the Dominion Coal Co. Much of the development work was carried out under his direction, including the surface plants at mines Nos. 2, 3, 5, 6, 7, 9, 10, 12, 14, and 15; the unloading plants at St. John, Quebec, Three Rivers, and Montreal; and its machine shops, railway branches, shops, etc.

The Dominion Bridge Co. acquired his services at the beginning of 1910, as its second vice-president and chief engineer, which position he holds at present. He is chief engineer of the St. Lawrence Bridge Co., contractors for the superstructure of the new Quebec Bridge.

The busy professional career briefly outlined in the foregoing fails to mention Mr. Duggan as president of the Engineering Alumni of the School of Practical Science, in 1894. He became associate member of the Canadian Society of Civil Engineers in 1888, and member in 1890. He was a member of its council during the years '94, '96, '98, '99, '04, '07 and '12. He was vice-president of the society in '97, 1900, '01, '02, '03 and '08. He is also a member of the Institution of Civil Engineers, of the American Society of Civil Engineers, and of the Canadian Mining Institute. He was vice-president of the Institute in '04, and is this year a member of its council.

The Engineering Society has always had a constant supporter and enthusiast in G. H. Duggan, '83. Last year the society put forth special efforts to have him attend their annual dinner, and were at the point of success when unforeseen business necessitated his remaining away. It was a great disappointment to the executive, but its statement has been endorsed by the new executive, that Mr. Duggan should be a guest and a speaker at the School dinner this year.

SCHOLARSHIPS

Among the applications for research scholarships in the Faculty of Applied Science that have been received by the Engineering Alumni Association none deal with any of the following problems:

First, Materials for Roadway Building.
Second, The Flow of Air in Pipes.
Third, The Properties of Masonry.
Fourth, The Design of Concrete Pipes.

These being subjects upon which no advanced research work has been done, and concerning which there is a great deal of important information lacking at the present time, the scholarship committee is disappointed that no applicant up to the present time has made any of them the basis of his request for research privileges. Some of the applications that have been received deal with problems of almost equal importance, and many of them appear as though they would lend themselves to profitable research. Several of those mentioned above, however, are in urgent need of investigation, and if any graduate has been contemplating applying for a scholarship on one of these or similar topic we feel sure that further study on his part of conditions as they at present exist, will convince hi mthat the time is opportune for active investigation.

LETTER TO THE EDITOR

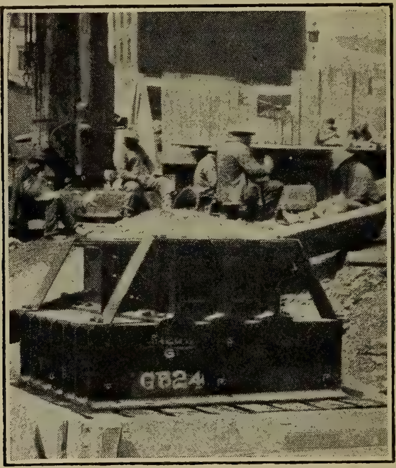
A UNIQUE COLUMN FOOTING CONSTRUCTION

Dear Sir:—

I enclose you herewith drawings and photos showing a design for a column base, adapted for use in building construction, made entirely of rolled shapes, which I have been using in my practice for a number of years, and which may prove of interest to the readers of Applied Science.

The beams are bolted up complete in the shop, including separators, and the top and bottom layer of beams likewise are bolted together, all ready for erection in one piece. The advantages over the conventional cast iron base are as follows:—

(1) In comparison with cast steel, it is both cheaper and more reliable. In my own experience, I have had cast steel bases develop cracks after having been erected, although they had been carefully annealed and inspected before leaving the shop. These had to be replaced after several stories of steel work had been erected, which entailed very considerable expense.



After Being Set.

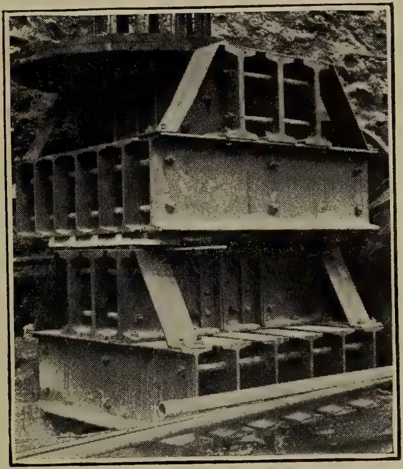
(2) In comparison with cast iron, it is as cheap and very much more reliable. In an experience extending over many years in the use of cast iron bases, I have known far too many to have developed cracks after they had been erected in the building, often entailing large expense for replacing them. For this reason I have not been using cast iron bases for the last ten years.

(3) This form of base is easier to set properly, being much more readily grouted.

(4) Stresses can be readily calculated (which cannot be said of the usual design of cast base), the conventional method of analysis

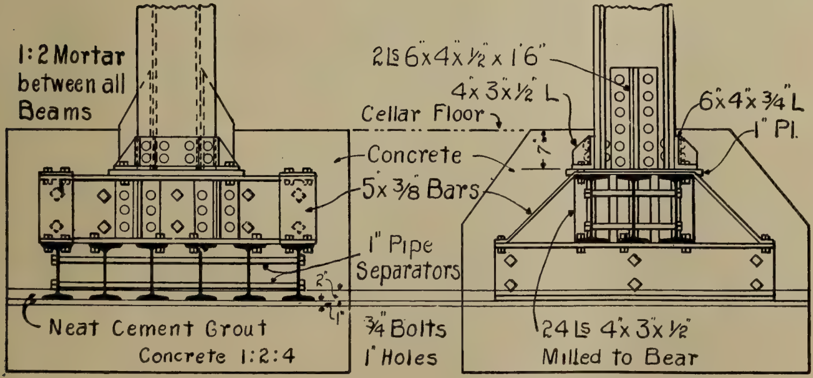
for shear, crippling and bending being accurate enough for all practical purposes.

I have used the design as shown in the prints for loads up to 1,600 tons, and by slight modifications in details it may be used for much larger loads. My preference is for shallow beams with heavy webs. If deep beams are used, webs may very likely have to be reinforced against crippling. In the top layer of the beams, I always use stiffeners ground to fit tight between the flanges to prevent crippling of the web of the beam, whether the calculations require them or not.



Stacked Up Ready for Shipping.

There should be plenty of pipe separators between the beams



Typical Column Footing with Square Base.

and in the top layer these should not be over six inches on center vertically and eight inches horizontally.

The space between beams is filled with a rich Portland cement mortar consisting of one part cement to two sand, to prevent corrosion in case the foundation is wet.

This type of base permits the use of a very simple detail at the bottom of the column.

Yours very truly,

E. W. STERN.

New York City, N.Y., May 14th, 1912.

NEW MEMBERS OF THE BOARD OF GOVERNORS

Mr. T. A. Russell and Lieut.-Col. A. E. Gooderham have been appointed by the Provincial Government to places on the Board of Governors of the University of Toronto, and will occupy the chairs previously occupied by Hon. W. T. White and Hon. T. W. Cruthers.

PROFESSOR MILLER IS PRESIDENT

Professor W. Lash Miller, of the Department of Chemistry, is president of the American Electrochemical Society, as a result of a recent appointment. Professor Miller will represent the society at the Congress of Applied Chemistry, which meets in Washington next September on the invitation of the President of the United States. This will be the first time the society has met in America, the last meeting, five years ago, having been held in Rome.

SOCIETY OF CHEMICAL INDUSTRY

The executive of the Society of Chemical Industry for 1912 and 1913 is made up as follows: Chairman, Wallace P. Cohoe; vice-chairmen, R. F. Ruttan, W. L. Goodwin, and Prof. J. Watson Bain; executive committee, H. P. Mills, O. H. Wurster, R. T. Mohan, of Hamilton; A. Neighorn, Milton; L. Hersey, C. F. Heebner, J. A. De Cew, Prof. W. Lash Miller, G. F. Guttman, N. N. Evans, T. H. Wardleworth, E. G. R. Ardagh.

The article on "Stereographic Measurement," in the May issue, is one of several articles on this subject appearing in the Canadian Engineer during the summer. Professor Anderson will give further information and examples concerning the stereo-comparator and its uses in his next article.

E. Andrews, '97, of Maen Offeren Slate Quarry Co., of Portmadoc, North Wales, was a visitor in the city recently with the British Manufacturers' Association. Mr. Andrews paid a visit to the School during his short stay in the city.

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EDITORIAL

As a direct result of the return to this office of subscription orders sent out in March, we have been able to reduce our monthly expense of mailing "Applied Science" to less than half its previous amount. This saving could not be effected in any other way. It is but a beginning. As soon as a reasonable number of further subscription orders are received we will again approach the Post Office Department at Ottawa for postal privileges upon them also, and we have the assurance that our request will receive consideration.

THE MATTER OF POSTAGE

The motive behind the idea is this: Our subscription price to graduates is one dollar per year. This does not defray the expense that twelve copies of "Applied Science" incurs. These copies cost a little over ten cents each to print and prepare for mailing. Thirty-six cents at least must, under the old rate, be added to this for postage. If we hold in this office a request, by post card or otherwise, that a person wishes to receive "Applied Science" throughout the year, and will send us one dollar for it later on, that advice will entitle us to a rate whereby his twelve copies will cost us, not thirty-six cents, but one and one-eighth cents to mail. The receipt of five hundred more of these orders will mean a further yearly saving of nearly $175.00 in postage. Will the graduates consider what this means to "Applied Science"? Drop us a letter or post card, and we will soon be able to show its meaning in actual figures.

Every graduate should and most graduates will send us the subscription price of the Journal. We must hasten to state that this is not a solicitation of dollars. The important point is that reduced postal privileges apply only to those on our mailing list who authorize us in some manner to mail the Journal to them, and then only for such a length of time as they mention in their advice.

If the previous subscription blank is at hand you will confer a great favor by using it: if not, a letter or post card will assist just as materially. The dollar subscription means a great deal to "Applied Science" when it reaches us, but it may attain an increased value of 35 p.c. if it is paid, or undertaken to be paid, at the beginning of the year of issue to which it applies.

Just now we are trying to secure subscription orders on copies to January, 1913. One-half of the copies which the order is to cover have already been received. The sooner we receive subscription orders the more value they are to us in this campaign. We will waste no time, on our part, in putting them to their desired use relative to postal rates.

EMPLOYMENT

Neither now nor at any time during the last month have we been able to fill the applications for men that have come in from companies engaged in various branches of engineering. At the time of writing we can supply about fifteen civils and six electricals or mechanicals with positions at very acceptable salaries. Such as this has been the condition of affairs since early in the month of May. It would be a very satisfactory state, providing all our men were satisfactorily employed, but we feel safe in saying that there is quite a number of undergraduates who should be at practical work during as much of the summer vacation as possible, and perchance there are a few graduates who would be deeply interested in the number and nature of applications for positions that are on file.

When, as is very often the case, a request is received, asking that a man capable of running a level or handling a party, let us say, be sent without delay to a place where his services are immediately required, it is necessary for us to act accordingly; and unless there is in our office a corresponding request from a man seeking employment of that nature it is extremely difficult to fill the vacancy. The remedy is in the interest of the School man and is likewise in his power. If every man who receives "Applied Science" would keep us informed throughout the time he is idle, by writing us from time to time, we would then be in a position to place him as soon as an application for such a man is received. This does not necessarily mean daily reminders or anything of that nature, but obviously a man might secure a position by other means, not inform us of it, and allow his name to remain on our list, perhaps preventing another of our men securing a position reserved by us for the first man.

There have been a number of cases, this year and last, where a man followed up prospective positions obtained at this office, but did not inform us whether he met with success or otherwise. His name remains upon our "Positions wanted" list, and the position which he succeeded in securing is also open, according to our list, for other men seeking employment to needlessly apply. By informing us as to whether or not he secured a position this deficiency would be eliminated, and no already-filled prospects need bother the man who is in search of a job.

THE SCHOLARSHIP IN MECHANICAL ENGINEERING

The scholarship offered at the beginning of last year by the Boiler Inspection and Insurance Company of this city, was won by Mr. A. S. Anderson, '13, for proficiency at the recent examinations. The scholarship is to the amount of $130.00, and is awarded to the candidate who takes the highest standing in Mechanical Engineering in the third year.

J. B. Challies, '04, has been appointed superintendent of the new water power branch of the Department of the Interior. This new organization will make surveys of Canada's water powers, and will gather data on stream fall.

E. W. Richards, '99, who has for some time been in charge of the stores and purchasing department of the Toronto Hydro-Electric System, has been appointed to the position of appraiser in the Customs Department of the Dominion Government, at Ottawa.

J. C. Gardner, '03, has been appointed to the position of chief engineer on the construction of the Good Roads of Welland County. Mr. Gardner is to establish a system of road maintenance and supervision, and is building one hundred and fifty miles of roads this season, at an expenditure of $400,000.

A. P. Linton, '06, until recently with the St. Lawrence Bridge Co., Montreal, has accepted an appointment with the Department of Public Works, Regina, as assistant Chief Engineer of Public Works in the Province of Saskatchewan.

WHAT OUR GRADUATES ARE DOING

E. R. Smithrim, '07, is engineer for the Watrous Electric Light, Power and Traction Co., Watrous, Sask.

R. S. Houston, '06, is employed by the Vulcan Iron Works Co., Winnipeg, Man.

W. R. Carson, '05, is chemical engineer for the Grasselli Chemical Co. of Cleveland, Ohio.

E. Wade, '04, is carrying on a contracting and building business at Welland, Ont.

J. L. Allan, '00, is assistant engineer construction department. Intercolonial Ry., Dartmouth, N.S.

Wm. L. Lawson, '93, is manager of the Great Western Sugar Refineries in Colorado.

C. F. Hanning, '89, is divisional engineer for the C.N.R., and is located at present at St. Eustache, Two Mountains, P.Q.

C. G. Townsend, '04, and J. M. Wilson, '08, of the firm of Wilson, Townsend & Saunders, contracting engineers, have their headquarters at Moose Jaw, Sask.

Ed. Harrison, '06, and G. M. Ponton, '09, are engaged in civil and mining engineering and land surveying, with offices in the Beveridge Building, Calgary, Alta.

D. D. MacLeod, '10, is engaged on hydrographic work for the Department of the Interior, at Calgary.

Wm. A. O'Flynn, '10, is in the chemical laboratories of the Copper Queen Smelter, at Douglas, Arizona.

R. B. Chandler, '11, has recently been appointed Assistant City Engineer of Saskatoon, Sask.

"Jeff" Taylor, '04, is stroke on the Argonaut eight that left recently to compete at the Henley regatta, and in Sweden.

J. Lanning, '11, a contributor in the May issue of "Applied Science," is with the Geological Survey of Canada. After having spent a month on work near St. John, N.B., his party left recently for Athelmar, B.C.

J. W. Tyrell, '83, is spending the summer in Europe, and will return about September.

R. G. Sneath, '11, is in charge of sewer and water works installation at Melfort, Saskatchewan, for McArthur & Underwood, of Saskatoon.

P. G. Cherry, '11, is manager of the circulation department of the "Canadian Engineer," Toronto.

E. O. Fuce, '03, has just resigned his position as engineer of the Municipality of Galt, to begin private practice in Calgary.

Mr. W. A. Hare, '99, president of the Hare Engineering Co., of Toronto, is on a business trip to Europe, and will be away for about six weeks.

A. B. Mitchell, '08, sailed recently for England as a member of the Canadian Bisley team, to compete in the July meet. Mr. Mitchell has just returned from Harvard, where he has been receiving special instruction in architecture.

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